Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

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THE SOCIOECONOMIC VALUE OF WATER IN CANADA

by

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Canada

[redacted]

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Research Paper # 5

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THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn
Director of Research

Abstract

This study was intended to clarify the concept of the economic value of water and to estimate the value of water in the Canadian economy.

Water use in Canada is highly concentrated in three non-manufacturing industries (agriculture, electric power and municipal waterworks) and in four manufacturing industries (chemical products, petroleum products, paper and allied products, and primary metal products). Total government expenditures on water-related activities were about 1% of GDP in 1981. Total public and private construction expenditures related to water were about 2% of GDP. Of these, one half were related to construction of electric power generation and a further third to municipal water supply and wastewater treatment.

The value of water can be measured by the willingness to pay for it. This depends heavily on the precise nature of alternatives and substitutes considered. Tentative estimates of average and total net willingness to pay for water in a number of uses were prepared based on available price and quantity data, estimates of the cost of alternatives, and on estimates of the elasticity of demand for water-based products. The total value of water in identified uses may range from \$7.5 to \$23.0 billion annually. These estimates must be interpreted with great caution.

The use of water in its natural setting appears to have very high value for Canadians. The value of sports fishing uses is comparable to that of hydroelectricity generation and the value of non-fishing recreation and non-participatory benefits is likely to be of the same magnitude. Finally, the long-lasting and largely irreversible nature of water development projects suggests a conservative stance in assessing them.

Résumé

Cette étude avait pour but de clarifier le concept de valeur économique de l'eau et d'estimer la valeur de l'eau dans l'économie canadienne.

Au Canada, l'utilisation de l'eau est hautement concentrée dans trois activités non-manufacturières (agriculture, production d'énergie électrique, approvisionnement des municipalités), et dans quatre activités manufacturières (produits chimiques, produits pétroliers, papier et produits connexes, produits de métaux primaires). Les déboursés gouvernementaux totaux reliés à des activités utilisant de l'eau ont représenté environ 1% du PDB (produit domestique brut) en 1981. Les déboursés publics et privés totaux dans le domaine de la construction d'infrastructures hydriques ont représenté environ 2% du PDB. La moitié de ces dépenses était reliée à la construction de centrales électriques et un autre tiers à la construction d'usines de filtration et de traitement des eaux usées.

La valeur monétaire de l'eau peut être mesurée par la volonté de payer pour celle-ci; ceci dépend énormément de la définition des alternatives et substituts envisagés . Des estimés provisoires des valeurs moyennes et totales de la volonté de payer pour l'eau utilisée dans plusieurs activités ont été préparés; ils sont basés sur les données de prix et de quantités disponibles à l'heure actuelle, sur des estimés du coût des alternatives pouvant être envisagées et sur des estimés de l'élasticité de la demande pour les produits dont les procédés de production nécessitent de l'eau. La valeur totale de l'eau pour les usages identifiés se situe entre \$7.5 et \$23 milliards annuellement. Ces estimés doivent être interprétés avec beaucoup de précaution.

L'utilisation de l'eau dans son cadre naturel semble avoir beaucoup de valeur pour les Canadiens. Les revenus de pêche sportive sont comparables à ceux provenant de la génération d'hydroélectricité et la valeur totale des activités récréationnelles autre que la pêche et des bénéfices non-participatifs pourrait être du même ordre de grandeur. Finalement, la nature quasi-irreversible des projets de développement hydriques et les effets prolongés qu'ils produisent suggèrent une attitude conservatrice dans l'évaluation de ceux-ci.

ACKNOWLEDGEMENTS

This study could not have been completed without the assistance of many people. First, I would like to thank Frank Quinn for formulating the objectives of the study and for his guidance in directing it to completion. I would also like to thank Don Tate of Environment Canada, Tony Friend of Statistics Canada and Harry Kitchen of Trent University for providing valuable source materials. Frank Quinn and Bernard Madé of the Inquiry, Tom Jones of Environment Canada and Jim Johnson of McMaster University provided valuable comments on an earlier draft. Finally, I thank Bill Grady for his assistance in expediting documents from Ottawa to Hamilton and in word processing.

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1 INTRODUCTION

1.1 Purpose of the Study:

This study was commissioned for the Inquiry on Federal Water Policy. The terms of reference specify that the objective is to estimate the value of water both to the major sectors of the Canadian economy and to Canadian society in general. The terms of reference also specify the following tasks:

1. Review statistical accounts of public and private expenditures and employment with regard to water-related goods and services in Canada.

2. Assess alternative approaches to evaluating water uses, such as value added, next best alternative and willingness to pay.

3. Estimate the value of water to various users (energy, industrial, agriculture, municipal, recreational, ecosystem support), insofar as dollar values can be assigned.

4. Consider other indicators of the value of water to Canadians for which economic data are unavailable or inadequate.

The specifications for the research state that establishing social and economic values for water is paramount given the need for governments to justify program expenditures and to allocate water to higher-valued uses in cases of shortage or conflict. Both reasons indicate that the research is being undertaken to provide guidance in the allocation of social resources, both the water itself (in times of shortage or conflict) and the human and physical resources represented by government programs undertaken to protect the water.

The specifications also refer to previous attempts to measure the value of water to the Canadian economy. For example, the Canada Water Year Book for 1981-82 estimates this value to be between $10 and $20 billion dollars annually. This study will attempt to refine these estimates. We must consider, however, whether overall estimates of this nature provide the best guidance in allocating water and resources to protect it.

1.2 Outline of the Study

Section two provides a broad view of the role of water in the Canadian economy. It brings together data on production, employment and expenditures in water related areas of the economy.

Section three attempts to clarify the concept of the value of water.It defines the value of water as the payment which would fully compensate users for the loss of their current access to water. A closely related concept is willingness to pay to preserve access to water. The total value of water in any use can be measured by the total willingness to pay for it. The average value of raw water (in the watercourse) is the average value of delivered water less the average cost of delivering it.

Section three also considers the circumstances under which average willingness to pay for water is a useful guide for policy decisions and examines a number of ways in which it can be measured.

Section four provides a rough estimate of the value of water in several uses in the Canadian economy. Based on the available literature, an average value is ascribed to each of the water uses recognized by the Inquiry. This is multiplied by an appropriate quantity measure and summed over regions and uses to derive an estimate of the total value of water to the Canadian economy, evaluated at average willingness to pay. For the uses identified in section 4, this value is estimated to lie between $7.5 and $23.0 billion dollars annually (at 1984 prices).

The economic measures discussed in section four cannot capture the full value of water to the Canadian people. Section five discusses a number of reservations about estimates of economic value and supplements them with a discussion of other benefits that Canadians derive from water. These benefits include recreational use other than fishing and non-participatory uses. The available evidence suggests that these benefits are very large and comparable in magnitude to sports fishing values.

Section six summarizes the findings of the study.

2 STATISTICAL DATA RELATED TO WATER

The purpose of this section is to review statistical accounts of public and private expenditure and employment in water using industries with the intention of consolidating their findings and evaluating them as a guide to resource allocation.

A number of studies have been undertaken under the auspices of Environment Canada in an attempt to document the importance of water to the Canadian economy. These include sections of the Canada Water Yearbook, 1981-82[1], and related in-house studies, a study of the role of water in the economy of Atlantic Canada[2], and a study of public expenditure in the water industry.[3]

Further information on a very detailed geographical basis is available in the forthcoming updated version of Human Activity in the Natural Environment, a joint project of Statistics Canada and Environment Canada.

These studies are reviewed briefly in section 2.1. In section 2.2 data on gross domestic product and employment are combined with national water use data to investigate the economic importance of water intensive industries. Section 2.3 summarizes the data presented in the Study of Public Expenditure in the Water Industry and analyses it. Section 2.4 discusses the role of these data in public policy analysis and section 2.5 summarizes our findings.

2.1 Review of Published Accounts

The Canada Water Year Book (CWYB) for 1981-82 contains an explicit attempt to place a value of the water resources of the Canadian economy. It recognizes two approaches to the measurement of value: the "value of production approach" and the "next best alternative" approach. In following the former approach, the CWYB (p. 10) reports that gross domestic product in water using industries in 1980 was $67 billion, expenditures on water related recreational activities were approximately $11 billion and that public expenditures on water systems in 1978 were $4 billion.

The CWYB recognizes that these overstate the "true economic value" of water because they reflect payments to all factors of production. However the Department of the Environment has continued to commission studies documenting the size of water related expenditures. Two of these are the Pinfold study[4] and the Public Expenditure study.[5]

The Pinfold study was undertaken to "substantiate the economic importance of water management in Atlantic Canada". It attempts to quantify the economic importance of water by tabulating contribution to gross domestic product (GDP) by major water consuming manufacturing industry, employment by industry, and value of municipal infra-structure expenditures and well drilling for the Atlantic provinces. The study concludes that placing a precise value on water is virtually impossible, but notes that the 10 manufacturing industries for which water use was available accounted for 75% of GDP and 80% of employment in manufacturing. It also notes significant discrepancies between industrial water use data from the 1976 Water Use Survey and the National Inventory of Municipal Waterworks and Wastewater Systems in Canada. Pinfold's basic results are extended to Canada in section 2.2 of the present study.

The Public Expenditure study tabulates data on public expenditure by federal, provincial and local governments on water related programmes. Very little analysis is undertaken, although the study notes difficulties arising from the unconsolidated nature of the government accounts. Total expenditures in 1981 amounted to $3.3 billion with the largest proportion in Water purification and supply followed by sewage collection and disposal. These results are summarized and analysed in section 2.3.

2.2 Contribution to GDP and Employment

A commonly used method of assessing the relative size of any economic activity is to consider its contribution to Gross Domestic Product (GDP). GDP is intended to measure the incomes arising from all forms of economic activity in Canada. It differs from Gross National Product (GNP) primarily by including incomes to foreigners arising in Canada and excluding incomes to Canadians arising from investments abroad. GDP in Canada, 1981, was $307.7 billion dollars.

Similarly, the relative size of an industry may be indicated by its employment as a share of the national total. Total employment in Canada, 1981, was approximately 10.5 million.

Table 2.1 shows selected statistics on contribution to GDP, employment and water use by selected industry. The water use data were provided by Environment Canada[6] and derive from the 1981 Water Use Survey supplement to the Annual Census of Manufacturing. Only ten industries previously identified as large water users were covered in the survey. Environment Canada has supplemented these data with estimates for some of the remaining manufacturing industries and for some important non-manufacturing uses. Agricultural water uses refer to 1980.

The employment data have been drawn from several sources. Manufacturing, Mining, Forestry and Electric Power are available from the Census of Manufacturing and related publications and are based on surveys of establishments. Similarly, municipal employment in waterworks can be estimated from data in Local Government Employment. However, the agriculture and total employment data derive from the labour force survey. These two sources are not precisely comparable, although the discrepancy may be quite small at the highly aggregated level of agricultural and total employment.

There are some important lacks of correspondance between the water use data and the GDP and employment data. First, municipal employment refers to waterworks employment only, while contribution to GDP includes entire local administration, much of which is clearly unrelated to water-based activity. Thus municipalities account for a much larger share of GDP than of employment in this data set. Secondly, both employment and GDP in agriculture refer to both irrigated and non-irrigated farms. Thus the relative importance of irrigated agriculture is overstated in this data. Finally, employment and contribution to GDP in the electical power industry refer to all forms of power generation, including hydroelectricity, while the water intake and consumption data refer only to withdrawal uses and do not include hydroelectric generation.

Only industries for which water use, employment and GDP data were available are reported. The selected industries account for 43% of GDP and 41% of employment.

Tables 2.2 and 2.3 present contribution to GDP and employment in the selected industries ranked by water intake. Water intake is heavily concentrated in a small number of industries, with electric power generation accounting for over 50% of identified water intake and 6 industries accounting for over 90% of the total use. These industries account for 12.81% of GDP (about $39.4 billion dollars in 1981) and 8.67% of employment (about 912 thousand jobs in 1981). Paper and Allied industries, chemical products and primary metal industries are the major manufacturing users of water.

Table 2.1
SELECTED STATISTICS BY SELECTED MAJOR INDUSTRY GROUP, 1981

TITLE	GDP (M$)	EMPLOY-MENT	INTAKE (Gl/A)	CON-SUMPTION (Gl/A)	NOTES
AGRICULTURE	100101.7	484000	3028.04	1609.29	A
METAL MINES	4930.4	68712	449.17	0.00	B,E
MINERAL FUELS	10877.4	39965	140.24	32.45	B
NON-METAL MINES	347.3	16391	58.90	0.00	B,E
FOOD AND BEVERAGES	8135.5	234077	429.84	30.71	B
TOBACCO PRODUCTS	450.1	8744	3.92	1.31	B,C
RUBBER AND PLASTICS	1820.5	61504	54.17	7.26	B
LEATHER PRODUCTS	492.0	26207	9.14	1.01	B,C
TEXTILES,KNITS,CLOTHING	4111.7	184018	123.67	5.19	B
WOOD INDUSTIRES	2970.3	112570	72.84	4.30	B
FURNITURE AND FIXTURES	1223.0	53361	26.58	0.00	B,C
PAPER AND ALLIED	6123.9	131024	2899.35	159.53	B
PRIMARY METAL INDUSTRIES	5085.8	125168	2718.60	37.68	B
METAL FABRICATING	5365.0	158832	30.21	1.22	B
MACHINERY	3787.3	108531	67.37	2.08	B,C
TRANSPORTATION EQMT	6278.1	178612	108.77	2.87	B
ELECTRICAL PRODUCTS	4281.9	127924	129.62	4.48	B,C
NON-METALLIC MINERALS	2062.5	55269	82.62	14.33	B
PETROLEUM AND COAL PROD.	936.4	22638	563.07	34.18	B
CHEMICAL PRODUCTS	4289.8	90186	2853.27	196.99	B
MISC. MANUFACTURING	1792.8	67573	28.58	2.60	B,C
ELECTRIC POWER	7785.2	70802	19280.83	168.24	B
TRADE	33396.2	1875000	1273.70	191.06	B
MUNICIPALITIES (WATERWK)	5942.6	10920	2867.59	430.14	B
TOTAL ALL INDUSTRIES	307721.5	10514600	37300.09	2936.915	D

SOURCES:
Statistics Canada 61-213 for Gross Domestic Product by Industry
Statistics Canada 31-203 for Manufacturing Employment
Statistics Canada 26-201 for Mining Employment
Statistics Canada 25-201 for Forestry Employment
Statistics Canada 57-202 for Electric Power Employment
Statistics Canada 72-009 for Municipal Waterworks employment
see also table W.1

TEXT OF NOTES
A. Water Uses from Canada Water Yearbook, 81-82, converted to annual.
B. Water Uses from Don Tate, Environment Canada
C. Water uses estimated from water/employment coefficients.
D. Water related totals refer only to identified uses.
E. Negative estimate of water consumption set to zeor.
Gl/a = billion litres/year = million cubic metre/year
M$ = millions of dollars

TABLE 2.2

CONTRIBUTION TO GROSS DOMESTIC PRODUCT BY SELECTED INDUSTRY GROUPS, RANKED BY WATER INTAKE, 1981

TITLE	--- CONTRIBUTION TO GDP--			-----INTAKE-----	
	(M$)	Distri-bution (%)	Cumu-lative (%)	(Gl/A)	Cumu-lative (%)
ELECTRIC POWER	7785	2.53	2.53	19281	51.69
AGRICULTURE	10182	3.31	5.84	3028	59.81
PAPER AND ALLIED	6124	1.99	7.83	2899	67.58
MUNICIPALITIES (WATERWK)	5943	1.93	9.76	2868	75.27
CHEMICAL PRODUCTS	4290	1.39	11.15	2853	82.92
PRIMARY METAL INDUSTRIES	5086	1.65	12.81	2719	90.21
TRADE	33396	10.85	23.66	1274	93.62
PETROLEUM AND COAL PROD.	936	0.30	23.96	563	95.13
METAL MINES	4930	1.60	25.57	449	96.34
FOOD AND BEVERAGES	8136	2.64	28.21	430	97.49
MINERAL FUELS	10877	3.53	31.74	140	97.86
ELECTRICAL PRODUCTS	4282	1.39	33.14	130	98.21
TEXTILES,KNITS,CLOTHING	4112	1.34	34.47	124	98.54
TRANSPORTATION EQMT	6278	2.04	36.51	109	98.84
NON-METALLIC MINERALS	2063	0.67	37.18	83	99.06
WOOD INDUSTRIES	2970	0.97	38.15	73	99.25
MACHINERY	3787	1.23	39.38	67	99.43
NON-METAL MINES	347	0.11	39.49	59	99.59
RUBBER AND PLASTICS	1821	0.59	40.08	54	99.74
METAL FABRICATING	5365	1.74	41.83	30	99.82
MISC. MANUFACTURING	1793	0.58	42.41	29	99.89
FURNITURE AND FIXTURES	1223	0.40	42.81	27	99.96
LEATHER PRODUCTS	492	0.16	42.97	9	99.99
TOBACCO PRODUCTS	450	0.15	43.11	4	100.00
TOTAL ALL INDUSTRIES	307722	100.00	100.00	37300	100.00

Source:
See Table 2.1

TABLE 2.3

CONTRIBUTION TO EMPLOYMENT BY SELECTED INDUSTRY GROUPS, RANKED BY WATER INTAKE, 1981

TITLE	------EMPLOYMENT--------			-----INTAKE-----	
	No. ('000)	Distri- bution	Cumu- lative	(Gl/A)	Cumu- lative
ELECTRIC POWER	71	0.67%	0.67%	19281	51.69%
AGRICULTURE	484	4.60%	5.28%	3028	59.81%
PAPER AND ALLIED	131	1.25%	6.52%	2899	67.58%
MUNICIPALITIES (WATERWK)	11	0.10%	6.63%	2868	75.27%
CHEMICAL PRODUCTS	90	0.86%	7.48%	2853	82.92%
PRIMARY METAL INDUSTRIES	125	1.19%	8.67%	2719	90.21%
TRADE	1875	17.83%	26.51%	1274	93.62%
PETROLEUM AND COAL PROD.	23	0.22%	26.72%	563	95.13%
METAL MINES	69	0.65%	27.38%	449	96.34%
FOOD AND BEVERAGES	234	2.23%	29.60%	430	97.49%
MINERAL FUELS	40	0.38%	29.98%	140	97.86%
ELECTRICAL PRODUCTS	128	1.22%	31.20%	130	98.21%
TEXTILES,KNITS,CLOTHING	184	1.75%	32.95%	124	98.54%
TRANSPORTATION EQMT	179	1.70%	34.65%	109	98.84%
NON-METALLIC MINERALS	55	0.53%	35.17%	83	99.06%
WOOD INDUSTRIES	113	1.07%	36.24%	73	99.25%
MACHINERY	109	1.03%	37.28%	67	99.43%
NON-METAL MINES	16	0.16%	37.43%	59	99.59%
RUBBER AND PLASTICS	62	0.58%	38.02%	54	99.74%
METAL FABRICATING	159	1.51%	39.53%	30	99.82%
MISC. MANUFACTURING	68	0.64%	40.17%	29	99.89%
FURNITURE AND FIXTURES	53	0.51%	40.68%	27	99.96%
LEATHER PRODUCTS	26	0.25%	40.93%	9	99.99%
TOBACCO PRODUCTS	9	0.08%	41.01%	4	100.00%
TOTAL ALL INDUSTRIES	10515	100.00%	100.00%	37300	100.00%

Source:
See Table 2.1

Tables 2.4 and 2.5 present contribution to GDP and employment by industry ranked by water consumption. Once again, water use is highly concentrated, with the top 6 industries accounting for more than 93% of consumption. Although the ranking has changed, essentially the same industries appear. Agriculture accounts for over 50% of identified consumption, but municipalities and electric power generation still appear among the top 6 water users. Paper and allied products continue to appear, while primary metals are displaced by the trade industries. The top 6 water consuming industries account for 22% of GDP (about $68 billion in 1981) and 25.3% of employment (about 2.7 million jobs) Water consumption may be high either because each unit of output in an industry requires much water or because the absolute size of the industry is large. The effects of industry size can be eliminated by calculating water use coefficients: water intake or consumption divided by employment or contribution to GDP. The resulting coefficient is a measure of the intensity of water use.

Tables 2.6 and 2.7 present contributions to GDP and employment by industry ranked by water intake per dollar of GDP and per employee. The leading two industries in Table 2.9 (Electric power and Municipal Waterworks) have intake/employee coefficients almost 10 times greater than the following four. The same six industries appear at the top of Table 2.8, but the drop off is not so great. Chemicals, petroleum, paper and primary metals are the most water intensive manufacturing industries by these measure. Tables 2.8 and 2.9 present comparable data for consumption intensity. Agriculture, municipalities and electric power continue to appear in the top 6, as do the chemical, petroleum, and paper and allied industries.

We conclude that agriculture, electric power and municipal waterworks are the most water intensive non-manufacturing industries on almost every definition. Chemical products, petroleum products, paper and allied industries and primary metals are the most water intensive manufacturing industries. Together, these seven industries account for 13.11% of GDP (about 40.3 billion) and 8.89% of employment (about 935,000 jobs), 91.7% of identified water intake and 89.76% of identified water consumption.

In all the preceding discussion, attention has been focused on withdrawal uses of water. Data on instream uses are very much harder to obtain on a consistent basis. Nevertheless, we should note that one of the biggest instream uses of water is for hydroelectric power generation. The employment and contribution to GDP of this activity is included in the above tables with the electric power industry.

TABLE 2.4

CONTRIBUTION TO GROSS DOMESTIC PRODUCT BY SELECTED INDUSTRY GROUPS, RANKED BY WATER CONSUMPTION, 1981

TITLE	--CONTRIBIUTION TO GDP--			---CONSUMPTION---	
	(M$)	Distri-bution	Cumu-lative	(Gl/A)	Cumu-lative
AGRICULTURE	10181.7	3.31%	3.31%	1609.29	54.80%
MUNICIPALITIES (WATERWKS)	5942.6	1.93%	5.24%	430.14	69.44%
CHEMICAL PRODUCTS	4289.8	1.39%	6.63%	196.99	76.15%
TRADE	33396.2	10.85%	17.49%	191.06	82.65%
ELECTRICAL POWER	7785.2	2.53%	20.02%	168.24	88.38%
PAPER AND ALLIED	6123.9	1.99%	22.01%	159.53	93.81%
PRIMARY METAL INDUSTRIES	5085.8	1.65%	23.66%	37.68	95.10%
PETROLEUM AND COAL PROD.	936.4	0.30%	23.96%	34.18	96.26%
MINERAL FUELS	10877.4	3.53%	27.50%	32.45	97.37%
FOOD AND BEVERAGES	8135.5	2.64%	30.14%	30.71	98.41%
NON-METALLIC MINERALS	2062.5	0.67%	30.81%	14.33	98.90%
RUBBER AND PLASTICS	1820.5	0.59%	31.40%	7.26	99.15%
TEXTILES,KNITS,CLOTHING	4111.7	1.34%	32.74%	5.19	99.32%
ELECTRICAL PRODUCTS	4281.9	1.39%	34.13%	4.48	99.48%
WOOD INDUSTRIES	2970.3	0.97%	35.10%	4.30	99.62%
TRANSPORTATION EQMT.	6278.1	2.04%	37.14%	2.87	99.72%
MISC. MANUFACTURING	1792.8	0.58%	37.72%	2.60	99.81%
MACHINERY	3787.3	1.23%	38.95%	2.08	99.88%
TOBACCO PRODUCTS	450.1	0.15%	39.10%	1.31	99.92%
METAL FABRICATING	5365.0	1.74%	40.84%	1.22	99.97%
LEATHER PRODUCTS	492.0	0.16%	41.00%	1.01	100.00%
METAL MINES	4930.4	1.60%	43.11%	0.00	100.00%
FURNITURE AND FIXTURES	1223.0	0.40%	41.40%	0.00	100.00%
NON-METAL MINES	347.3	0.11%	41.51%	0.00	100.00%
TOTAL ALL INDUSTRIES	307722	100.00%	100.00%	2936.9	100.00%

Source:
See Table 2.1

TABLE 2.5

CONTRIBUTION TO EMPLOYMENT BY SELECTED INDUSTRY GROUPS, RANKED BY WATER CONSUMPTION, 1981

TITLE	EMPLOYMENT			CONSUMPTION	
	No. ('000)	Distri-bution	Cumu-lative	(Gl/A)	Cumu-lative
AGRICULTURE	484	4.60%	4.60%	1609.29	54.80%
MUNICIPALITIES (WATERWK)	11	0.10%	4.71%	430.14	69.44%
CHEMICAL PRODUCTS	90	0.86%	5.56%	196.99	76.15%
TRADE	1875	17.83%	23.40%	191.06	82.65%
ELECTRIC POWER	71	0.67%	24.07%	168.24	88.38%
PAPER AND ALLIED	131	1.25%	25.32%	159.53	93.81%
PRIMARY METAL INDUSTRIES	125	1.19%	26.51%	37.68	95.10%
PETROLEUM AND COAL PROD.	23	0.22%	26.72%	34.18	96.26%
MINERAL FUELS	40	0.38%	27.10%	32.45	97.37%
FOOD AND BEVERAGES	234	2.23%	29.33%	30.71	98.41%
NON-METALLIC MINERALS	55	0.53%	29.85%	14.33	98.90%
RUBBER AND PLASTICS	62	0.58%	30.44%	7.26	99.15%
TEXTILES,KNITS,CLOTHING	184	1.75%	32.19%	5.19	99.32%
ELECTRICAL PRODUCTS	128	1.22%	33.41%	4.48	99.48%
WOOD INDUSTIRES	113	1.07%	34.48%	4.30	99.62%
TRANSPORTATION EQMT	179	1.70%	36.18%	2.87	99.72%
MISC. MANUFACTURING	68	0.64%	36.82%	2.60	99.81%
MACHINERY	109	1.03%	37.85%	2.08	99.88%
TOBACCO PRODUCTS	9	0.08%	37.93%	1.31	99.92%
METAL FABRICATING	159	1.51%	39.44%	1.22	99.97%
LEATHER PRODUCTS	26	0.25%	39.69%	1.01	100.00%
METAL MINES	69	0.65%	40.35%	0.00	100.00%
FURNITURE AND FIXTURES	53	0.51%	40.85%	0.00	100.00%
NON-METAL MINES	16	0.16%	41.01%	0.00	100.00%
TOTAL ALL INDUSTRIES	10515	100.00%	100.00%	2936.92	100.00%

Source:
See Table 2.1

TABLE 2.6

CONTRIBUTION TO GDP AND EMPLOYMENT BY SELECTED MAJOR INDUSTRY GROUPS, RANKED BY WATER INTAKE PER DOLLAR OF GNP

TITLE	GDP		EMPLOYMENT		COEF-FICIENT
	(M$)	Cumu-lative	('000)	Cumu-lative	
ELECTRIC POWER	7785.2	2.53%	71	0.67%	2476.60
CHEMICAL PRODUCTS	4289.8	3.92%	90	1.53%	665.13
PETROLEUM AND COAL PROD.	936.4	4.23%	23	1.75%	601.31
PRIMARY METAL INDUSTRIES	5085.8	5.88%	125	2.94%	534.55
MUNICIPALITIES (WATERWK)	5942.6	7.81%	11	3.04%	482.55
PAPER AND ALLIED	6123.9	9.80%	131	4.29%	473.45
AGRICULTURE	10181.7	13.11%	484	8.89%	297.40
NON-METAL MINES	347.3	13.22%	16	9.05%	169.59
METAL MINES	4930.4	14.83%	69	9.70%	91.10
FOOD AND BEVERAGES	8135.5	17.47%	234	11.93%	52.84
NON-METALLIC MINERALS	2062.5	18.14%	55	12.45%	40.06
TRADE	33396.2	28.99%	1875	30.28%	38.14
ELECTRICAL PRODUCTS	4281.9	30.38%	128	31.50%	30.27
TEXTILES,KNITS,CLOTHING	4111.7	31.72%	184	33.25%	30.08
RUBBER AND PLASTICS	1820.5	32.31%	62	33.84%	29.76
WOOD INDUSTIRES	2970.3	33.28%	113	34.91%	24.52
FURNITURE AND FIXTURES	1223.0	33.67%	53	35.41%	21.73
LEATHER PRODUCTS	492.0	33.83%	26	35.66%	18.58
MACHINERY	3787.3	35.07%	109	36.69%	17.79
TRANSPORTATION EQMT	6278.1	37.11%	179	38.39%	17.33
MISC. MANUFACTURING	1792.8	37.69%	68	39.04%	15.94
MINERAL FUELS	10877.4	41.22%	40	39.42%	12.89
TOBACCO PRODUCTS	450.1	41.37%	9	39.50%	8.71
METAL FABRICATING	5365.0	43.11%	159	41.01%	5.63
TOTAL ALL INDUSTRIES	307721.5	100.00%	10515	100.00%	121.21

SOURCES:
Statistics Canada 61-213 for Gross Domestic Product by Industry
Statistics Canada 31-203 for Manufacturing Employment

TABLE 2.7

CONTRIBUTION TO GDP AND EMPLOYMENT BY SELECTED MAJOR INDUSTRY GROUPS, RANKED BY WATER INTAKE PER EMPLOYEE, 1981

TITLE	GDP		EMPLOYMENT		COEF-FICIENT
	(M$)	Cumu-lative	('000)	Cumu-lative	
ELECTRIC POWER	7785.2	2.53%	71	0.67%	272.32
MUNICIPALITIES (WATERWK)	5942.6	4.46%	11	0.78%	262.60
CHEMICAL PRODUCTS	4289.8	5.86%	90	1.63%	31.64
PETROLEUM AND COAL PROD.	936.4	6.16%	23	1.85%	24.87
PAPER AND ALLIED	6123.9	8.15%	131	3.10%	22.13
PRIMARY METAL INDUSTRIES	5085.8	9.80%	125	4.29%	21.72
METAL MINES	4930.4	11.40%	69	4.94%	6.54
AGRICULTURE	10181.7	14.71%	484	9.54%	6.26
NON-METAL MINES	347.3	14.83%	16	9.70%	3.59
MINERAL FUELS	10877.4	18.36%	40	10.08%	3.51
FOOD AND BEVERAGES	8135.5	21.00%	234	12.31%	1.84
NON-METALLIC MINERALS	2062.5	21.67%	55	12.83%	1.49
ELECTRICAL PRODUCTS	4281.9	23.07%	128	14.05%	1.01
RUBBER AND PLASTICS	1820.5	23.66%	62	14.63%	0.88
TRADE	33396.2	34.51%	1875	32.47%	0.68
TEXTILES,KNITS,CLOTHING	4111.7	35.85%	184	34.22%	0.67
WOOD INDUSTRIES	2970.3	36.81%	113	35.29%	0.65
MACHINERY	3787.3	38.04%	109	36.32%	0.62
TRANSPORTATION EQMT	6278.1	40.08%	179	38.02%	0.61
FURNITURE AND FIXTURES	1223.0	40.48%	53	38.52%	0.50
TOBACCO PRODUCTS	450.1	40.63%	9	38.61%	0.45
MISC. MANUFACTURING	1792.8	41.21%	68	39.25%	0.42
LEATHER PRODUCTS	492.0	41.37%	26	39.50%	0.35
METAL FABRICATING	5365.0	43.11%	159	41.01%	0.19
TOTAL ALL INDUSTRIES	307721.5	100.00%	10515	100.00%	3.55

SOURCES:
See Table 2.1

TABLE 2.8

CONTRIBUTION TO GDP AND EMPLOYMENT BY SELECTED MAJOR INDUSTRY GROUPS, RANKED BY WATER CONSUMPTION/GDP COEFFICIENTS, 1981

TITLE	---------GDP------		--EMPLOYMENT----		COEF-FICIENT
	(M$)	Cumu-lative	('000)	Cumu-lative	
AGRICULTURE	10182	3.31%	484	4.60%	158.06
MUNICIPALITIES (WATERWK)	5943	5.24%	11	4.71%	72.38
CHEMICAL PRODUCTS	4290	6.63%	90	5.56%	45.92
PETROLEUM AND COAL PROD.	936	6.94%	23	5.78%	36.50
PAPER AND ALLIED	6124	8.93%	131	7.03%	26.05
ELECTRIC POWER	7785	11.46%	71	7.70%	21.61
PRIMARY METAL INDUSTRIES	5086	13.11%	125	8.89%	7.41
NON-METALLIC MINERALS	2063	13.78%	55	9.42%	6.95
TRADE	33396	24.63%	1875	27.25%	5.72
RUBBER AND PLASTICS	1821	25.23%	62	27.83%	3.99
FOOD AND BEVERAGES	8136	27.87%	234	30.06%	3.77
MINERAL FUELS	10877	31.40%	40	30.44%	2.98
TOBACCO PRODUCTS	450	31.55%	9	30.52%	2.91
LEATHER PRODUCTS	492	31.71%	26	30.77%	2.05
MISC. MANUFACTURING	1793	32.29%	68	31.41%	1.45
WOOD INDUSTIRES	2970	33.26%	113	32.48%	1.45
TEXTILES,KNITS,CLOTHING	4112	34.59%	184	34.23%	1.26
ELECTRICAL PRODUCTS	4282	35.99%	128	35.45%	1.05
MACHINERY	3787	37.22%	109	36.48%	0.55
TRANSPORTATION EQMT	6278	39.26%	179	38.18%	0.46
METAL FABRICATING	5365	41.00%	159	39.69%	0.23
METAL MINES	4930	42.60%	69	40.35%	0.00
FURNITURE AND FIXTURES	1223	43.00%	53	40.85%	0.00
NON-METAL MINES	347	43.11%	16	41.01%	0.00
				0	
TOTAL ALL INDUSTRIES	307722	100.00%	10515	100.00%	

Source:
See Table 2.1

TABLE 2.9

CONTRIBUTION TO GDP AND EMPLOYMENT BY SELECTED MAJOR INDUSTRY GROUPS, RANKED BY WATER CONSUMPTION/EMPLOYEE COEFFICIENTS, 1981

TITLE	---------GDP------		--EMPLOYMENT----		COEF-FICIENT
	(M$)	Cumu-lative	('000)	Cumu-lative	
MUNICIPALITIES (WATERWK)	5943	1.93%	10.9	0.10%	39.39
AGRICULTURE	10182	5.24%	484.0	4.71%	3.32
ELECTRIC POWER	7785	7.77%	70.8	5.38%	2.38
CHEMICAL PRODUCTS	4290	9.16%	90.2	6.24%	2.18
PETROLEUM AND COAL PROD.	936	9.47%	22.6	6.45%	1.51
PAPER AND ALLIED	6124	11.46%	131.0	7.70%	1.22
MINERAL FUELS	10877	14.99%	40.0	8.08%	0.81
PRIMARY METAL INDUSTRIES	5086	16.65%	125.2	9.27%	0.30
NON-METALLIC MINERALS	2063	17.32%	55.3	9.80%	0.26
TOBACCO PRODUCTS	450	17.46%	8.7	9.88%	0.15
FOOD AND BEVERAGES	8136	20.11%	234.1	12.11%	0.13
RUBBER AND PLASTICS	1821	20.70%	61.5	12.69%	0.12
TRADE	33396	31.55%	1875.0	30.52%	0.10
LEATHER PRODUCTS	492	31.71%	26.2	30.77%	0.04
MISC. MANUFACTURING	1793	32.29%	67.6	31.41%	0.04
WOOD INDUSTIRES	2970	33.26%	112.6	32.48%	0.04
ELECTRICAL PRODUCTS	4282	34.65%	127.9	33.70%	0.04
TEXTILES,KNITS,CLOTHING	4112	35.99%	184.0	35.45%	0.03
MACHINERY	3787	37.22%	108.5	36.48%	0.02
TRANSPORTATION EQMT	6278	39.26%	178.6	38.18%	0.02
METAL FABRICATING	5365	41.00%	158.8	39.69%	0.01
NON-METAL MINES	347	41.11%	16.4	39.85%	0.00
METAL MINES	4930	42.72%	68.7	40.50%	0.00
FURNITURE AND FIXTURES	1223	43.11%	53.4	41.01%	0.00
TOTAL ALL INDUSTRIES	307722	100.00%	10514.6	100.00%	0.28

Source:
See Table 2.1

2.3 Public Expenditures

Data on public expenditure on water related programs have been conveniently summarized in a recent study prepared by Environment Canada. This study extracted data on water related expenditures by province from Statistics Canada's reports on Local, Provincial and Federal Government Finance. Only national totals are reported here.

Tables 2.10 and 2.11 present gross expenditure by all levels on government on water related programs. Both capital and current operating expenditures are included. Percentage distributions have been prepared for this report.

The tables present direct federal expenditures and gross provincial and local expenditures. Since some of the provincial and local expenditures are financed by federal transfers, these must be deducted to obtain net provincial and local expenditure. Total expenditure is the sum of federal direct, federal transfer and local, and provincial net expenditures. Expenditures by provincial electrical utilities are not included in these totals.

Total expenditure is in the range of $3 billion 1981 dollars or approximately 1% of GDP. More than 80% of these expenditures are incurred by the provincial and local governments, primarily for water supply and sewage disposal. Expenditure on these two items alone exceeded $2.6 billion dollars in 1981, accounting for 79.8% of all water related expenditures.

Federal direct expenditures were almost exclusively devoted to water transportation. Transfers amounted to only 2.74% of total expenditure and were mainly concentrated in subsidies to sewage collection and disposal.

Much expenditure on fish and game and on recreation is directly related to water based activities. Table 2.12 presents total expenditure by all levels of government on these two items. About .5 billion dollars were spent on fish and game and about $1.9 billion were spent on recreation in 1980-81.

The vast majority of the expenditures are incurred by municipalities (57.8%) and provincial governments (24.18%), overwhelmingly for recreation. Federal direct expenditures are concentrated in the area of wildlife.

TABLE 2.10

GROSS EXPENDITURE BY FEDERAL, PROVINCIAL AND LOCAL GOVERNMENTS ON WATER-RELATED PROGRAMS, CANADA, 1979-80
(millions of dollars)

	Federal direct	----Local and Provincial-------- gross	less transfers	net	Total All Gov't
Water Resources Conservation and development		52.0	-5.3	46.7	52.0
Water Transport	364.5	33.9	-12.4	21.5	398.4
Water Purification and supply		1344.7		1344.7	1344.7
Sewage Collection and disposal		856.6	-84.0	772.6	856.6
Pollution Control	30.2	80.0		80.0	110.2
All Program Groups	394.7	2367.3	-101.8	2265.5	2762.0

PERCENTAGE DISTRIBUTION OF GOVERNMENT EXPENDITURE ON WATER RELATED PROGRAMS, CANADA, 1979-80

	Federal direct (%)	----Local and Provincial------ gross (%)	less transfers (%)	net (%)	Total All Gov't (%)
Water Resources Conservation and development		1.88	-0.19	1.69	1.88
Water Transport	13.20	1.23	-0.45	0.78	14.43
Water Purification and supply		48.69		48.69	48.69
Sewage Collection and disposal		31.01	-3.04	27.97	31.01
Pollution Control	1.09	2.90		2.90	3.99
All Program Groups	14.29	85.71	-3.69	82.02	100.00

Source:
Computed from Public Expenditure in the Water Industry,1979-81 Table lA.
Original data from Statistics Canada 68-204, 68-207, 68-211.

TABLE 2.11

GROSS EXPENDITURE BY FEDERAL, PROVINCIAL AND LOCAL GOVERNMENTS ON WATER-RELATED PROGRAMS, CANADA, 1980-81
(millions of dollars)

	Federal direct	----Local and Provincial-------- gross	less transfers	net	Total All Gov't
Water Resources Conservation and development		31.6	-6.5	25.1	31.6
Water Transport	426.9	60.2	-13.5	46.8	487.2
Water Purification and supply		1643.2		1643.2	1643.2
Sewage Collection and disposal		959.6	-69.4	890.2	959.6
Pollution Control	35.5	103.0		103.0	138.5
All Program Groups	462.4	2797.6	-89.4	2708.2	3260.0

PERCENTAGE DISTRIBUTION OF GOVERNMENT EXPENDITURE ON WATER RELATED PROGRAMS, CANADA, 1980-81

	Federal direct (%)	----Local and Provincial------ gross (%)	less transfers	net (%)	Total All Gov't
Water Resources Conservation and development		0.97	-0.20	0.77	0.97
Water Transport	13.10	1.85	-0.41	1.43	14.94
Water Purification and supply		50.40		50.40	50.40
Sewage Collection and disposal		29.44	-2.13	27.31	29.44
Pollution Control	1.09	3.16		3.16	4.25
All Program Groups	14.18	85.82	-2.74	83.07	100.00

Source:
Computed from Public Expenditure in the Water Industry,1979-81 Table 2A.
Original data from Statistics Canada 68-204, 68-207, 68-211.

Table 2.12

GROSS EXPENDITURE BY ALL LEVELS OF GOVERNMENT ON FISH AND GAME
AND ON RECREATION
(millions of dollars)

1979-80 (1

		)	1980-81 (2)	
	(M$)	(%)	(M$)	(%)
Federal Direct Expenditure:				
Fish and Game	251.7	12.63%	292.5	12.35%
Recreation	99.4	4.99%	134.3	5.67%
Provincial Expenditure:				
Fish and Game	154.8	7.77%	167.7	7.08%
Recreation	358.8	18.00%	404.9	17.10%
Local Expenditure				
Recreation	1128.2	56.61%	1369.0	57.80%
Totals	1992.8	100.00%	2368.4	100.00%

(1) Local Government Expenditures for calendar 1979
(2) Local Government Expenditures for calendar 1981

Source: Computed from Public Expenditure in the Water Industry,1979-1981 (Tables 1F and 2F)
Original data from Statistics Canada 68-204, 68-207, 68-211

An alternative view of public expenditure on water related projects is provided by capital projects related to water. Table 2.13 presents total capital expenditure on water related projects by all levels of government and by public and private agents combined.

These data differ from those in Table 2.11 in excluding current operating expenditures and expenditure on machinery and equipment. Moreover, the provincial and federal data in Table 2.11 are on a fiscal year basis whereas the data in Table 2.13 are on a calendar year basis.

Almost half of the $6.5 billion total was represented by construction of generating stations and associated dams and control structures. It is important to realize that capital expenditures by Crown electical utilities are not classified as government expenditures. Government expenditures proper were about $1.8 billion, or 27% of the total. These were concentrated in water supply and waste treatment. Generating stations and water works (including sewage and treatment) accounted for 81% of total capital expenditures.

We conclude that public expenditures on water related projects are large in absolute terms, although they represent but a small fraction of total public expenditures. They are incurred primarily by local and provincial governments and are overwhelmingly concentrated in the provision and treatment of municipal water and waste and in the construction of electrical power generating stations.

2.4 Evaluation

These statistics provide valuable information on the role of water using industries in the Canadian economy. In particular they show that the intake and consumption of water are highly concentrated in a small number of industries, namely agriculture, municipal water supply and waste treatment, electric power generation and certain manufacturing industries. These are the chemical products, petroleum and coal products, paper and allied products, and primary metals industries. Together, these industries play an important role in the economy, accounting for over 13% of GDP and 8% of employment. In addition, we have seen that large capital expenditures on water related activities are made by public and private agencies. Once again, these are heavily concentrated on municipal water supply and waste treatment and on electric power generation. Large public expenditures are also made to construct and operate recreational facilities, many of which are closely related to water based activities.

Table 2.13

TOTAL EXPENDITURE ON CONSTRUCTION IN WATER RELATED ACTIVITIES, 1981
(million dollars) (a)

	Local	Provin-cial	Federal	All Gov't	All Public & Private
Water transport		43.9	99.7	143.6	336.0
Waterworks	(b)	51.2	17.7	68.9	899.2
Sewers and Treatment(c)	1328.9	147.7	16.0	1492.6	1227.8
Dams and Resevoirs		65.5	7.7	73.3	98.6
Irrigation		26.0	1.4	27.5	158.3
Generating Stations			6.0	6.0	3144.7
Outdoor Recreation		3.6	2.7	6.4	64.0
Total	1328.9	338.1	151.4	1818.3	5928.6

PERCENTAGE DISTRIBUTION OF CONSTRUCTION EXPENDITURES ON
WATER RELATED ACTIVITIES, 1981

	Local (%)	Provin-cial (%)	Federal (%)	All Gov't (%)	All Public & Private (%)
Water transport		12.98	65.87	7.90	5.67
Waterworks	(b)	15.15	11.69	3.79	15.17
Sewers and Treatment	100.00	43.70	10.57	82.09	20.71
Dams and Resevoirs		19.38	5.13	4.03	1.66
Irrigation		7.70	0.95	1.51	2.67
Generating Stations		0.00	3.98	0.33	53.04
Outdoor Recreation		1.08	1.81	0.35	1.08
Total	100.00	100.00	100.00	100.00	100.00

Source:
Calculated from Public Expenditure in the Water Industry, 1979-81, Tables 4A and 4B. Original data from Statistics Canada, 64-201, were subject to revision.

Notes:
(a) Includes value of labour content and cost of materials, excludes Machinery.
(b) Local Waterworks expenditures included in sewers and treatment.
(c) All government expenditures exceed all public and private expenditurks for this item in the source document. This may reflect differences in timing or in classification in the original documents

These data are most useful in identifying those segments of the market economy which are most likely to be affected by changes in water availability. This information can guide the analysis and evaluation of any public project or policy which affects water supply or demand. By focussing detailed analysis on those industries or activities which are most affected by water policies, proposed projects can be evaluated more efficiently and effectively.

Do these data help us estimate the "economic value of water"? The simple answer is no. A detailed discussion must be postponed to section 3, but we can note here that all senses of the word "value" ultimately refer to a commodity's worth in achieving some end. These data tell us something about how much income and employment arise in activities which use a lot of water. They tell us nothing about how <u>essential</u> water is to these activities and how essential these activities are to our welfare. In particular, they tell us nothing about the ease or difficulty with which water using industries could economize on their use of water if the need arose and they tell us nothing about the ease or difficulty of finding substitutes for these industries should they be threatened by diminished water supplies.

<u>Summary</u>

The discussion of this section may be summarized as follows:

1. A number of efforts have been made to estimate the value of water to the Canadian economy by tabulating statistics on economic activity in water related industries. These have been reviewed and extended in this section.

2. Agriculture, electric power and municipal waterworks are the most water intensive non-manufacturing industries on almost every definition. Chemical products, petroleum products, paper and allied industries and primary metals are the most intensive manufacturing industries. Together, these seven industries account for 13.11% of GDP (about 40.3 billion in 1981), 8.89% of employment (about 935 thousand jobs in 1981), 91.7% of identified water intake and 89.76% of identified water consumption.

3. Total government expenditure on water related programs is in the range of $3 billion 1981 dollars or approximately 1% of GDP. More than 80% of these expenditures are incurred by the provincial and local governments, primarily for water supply and sewage disposal. Expenditure on these two items alone exceeded $2.6 billion in 1981, accounting for 79.8% of all water related expenditures by governments.

4. Public expenditure on fish and game and on recreation totaled about $2.4 billion in 1981. These expenditures were overwhelmingly dominated by provincial and local expenditures on recreation.

5. Public and private construction expenditure on water related programs amounted to $6.5 billion in 1981. Almost half was spent on construction of electric power generation and a further third was spent on municipal water supply and waste treatment.

6. Although very useful in planning and evaluating public water policies, these data do not provide information on the economic value of water to the Canadian economy.

3 ALTERNATIVE APPROACHES TO ESTIMATING THE VALUE OF WATER

There is no single answer to the question "what is the value of water to the Canadian economy" because this value depends on the definition of the term "value" and on the alternatives considered. In the first part of this section, we will review a number of uses of the term "value" and define it for our purposes as the quantity of other commodities a person is willing to exchange for an item. This definition can incorporate a wide variety of considerations normally treated as non-monetary. The concept of value is closely related to the notions of willingness to pay and consumers' surplus which are used in cost-benefit analysis and have been highly developed in attempts to measure the benefits of water pollution control, particularly in the United States. In section 3.2 we review the theory of benefit measurement and discuss how we could measure the value of water if sufficient information were available. In the light of this discussion we assess in section 3.3 a number of techniques which have been proposed or used to measure the value of water in Canada and elsewhere. Section 4 presents empirical estimates of the willingness to pay for water in Canada.

3.1 The Concept of Value

The common meaning of the term value is worth, desirablility, or utility.[7] Objects have value, therefore, insofar as they contribute to some desirable or useful goal. Since the time of Adam Smith it has been conventional to distinguish between the value of a commodity in use and its value in exchange. The notion of use value was not developed by Smith, but evidently it refers to the common meaning of desirability. In modern economics, value means exchange value. In general, the exchange value of a commodity is the quantity of other goods and services for which it will exchange. Since money is the medium of exchange we can usually measure the value of a commodity by its price, that is, the quantity of money it will exchange for.

The common and technical meanings of value can be reconciled by appeal to the utilitarian proposition that each person is the best judge of the contribution of any commodity to his or her own welfare. The utility of a commodity can thus be judged by how much a person is willing to pay to aquire it.

When an exchange actually occurs, the monetary value of the goods traded reflects both what the buyer is willing to pay for the goods and what the seller is willing to accept. For this reason we have little difficulty understanding a statement like "the value of a dozen eggs is $1.20." It means both that the buyer of the eggs is willing to trade his claim to $1.20 worth of other goods and services for the eggs and that the seller is willing to accept the $1.20 in compensation for giving up the eggs. If voluntary exchange is not taking place, however, we must distinguish between the value of a good to the buyer and to the seller. Its value to the seller (i.e. its current owner) is the minimum amount he will voluntarily accept to give it up. Its value to the buyer is the maximum amount he is willing to pay to obtain it.

There may be some goods which are so precious that we would never give them up voluntarily -- they are "priceless". Nevertheless, we may only be willing to pay a finite amount of money to prevent them from being taken away from us. This amount is sometimes treated as the value of the good in question but it clearly does not fully reflect the loss imposed upon us in this case. The distinction lies in the implied circumstances of the trade. In the first case, we are assumed to have the right to enjoy the good and we are deciding whether or not to give it up. In the second case, we have already lost the right to the good and are deciding only whether or not to buy it back. The distinction is crucial in evaluating the loss of customary rights to use water.

We must also distinguish between the marginal value of a commodity, which is what we are willing to pay for one additional unit or willing to accept to surrender one unit, and the total value of the commodity, which is what we are willing to pay rather than do without the commodity altogether. Of course there may be intermediate cases in which we consider exchanging a large amount of the commodity but not our entire holdings.

It is well known that the marginal value of a commodity can be low, even though its total value is high or infinite. The classical example compares the value of diamonds and water. Because water is so abundant, people are willing to pay only a very little for one additional unit, even though they would be willing to pay much more to avoid being totally deprived of water than they would to avoid being totally deprived of diamonds.

The appropriate concept of value depends on the question at hand. To evaluate a public policy which causes a small change in water quantity or quality we would like to know the marginal value. To evaluate a public policy which eliminates or greatly reduces a particular use, for example, recreational canoeing, we need an approximation to the total value of water in this use, namely what recreational canoeists would willingly accept in exchange for their right to canoe.

For the purposes of this report, we will define the value of water to Canadians as the quantity of other goods they would be willing to accept in exchange for their right to use Canadian water. In this sense, the total value of water in Canada is probably infinite. For public decisions, however, the relevant questions concern the marginal value of water in its various current uses and the total value of water in any use which might be largely eliminated by future development. The value of water thus calculated may be finite. It will, however, differ greatly depending upon the exact area of the country and the precise nature of the projects under consideration. For this reason, any attempt to measure the total value of water in Canada must be interpreted with extreme caution.

3.2 Theoretical Measures of Value

The definition of value given above is equivalent to the concept of benefit in cost benefit analysis. In particular, the value of water is a measure of the benefit Canadians receive from their access to water. This benefit cannot be meaningfully discussed without specifying the alternative being considered. Thus the value of drinking water from Lake Ontario cannot be measured without specifying what the alternative sources would be. This point will become crucial in interpreting the results of section 4.

The equivalence of the concept of "value" and the concept of "benefit" allow us to appeal to the theory of Cost-Benefit Analysis when discussing the value of Canadian water. Fortunately a number of excellent studies of the benefits of water pollution control in the United States have recently appeared and the interested reader is referred to them for detailed discussions of the ideas presented below.[8]

We begin by noting that water confers benefits on Canadians either directly, as in the pleasure derived from swimming in a lake, or indirectly through its contribution to a product such as electric power which does yield benefits directly. In both cases, Canadians can benefit either as consumers of water or related products or as a producers of the water based product. We first consider the case of direct benefits.

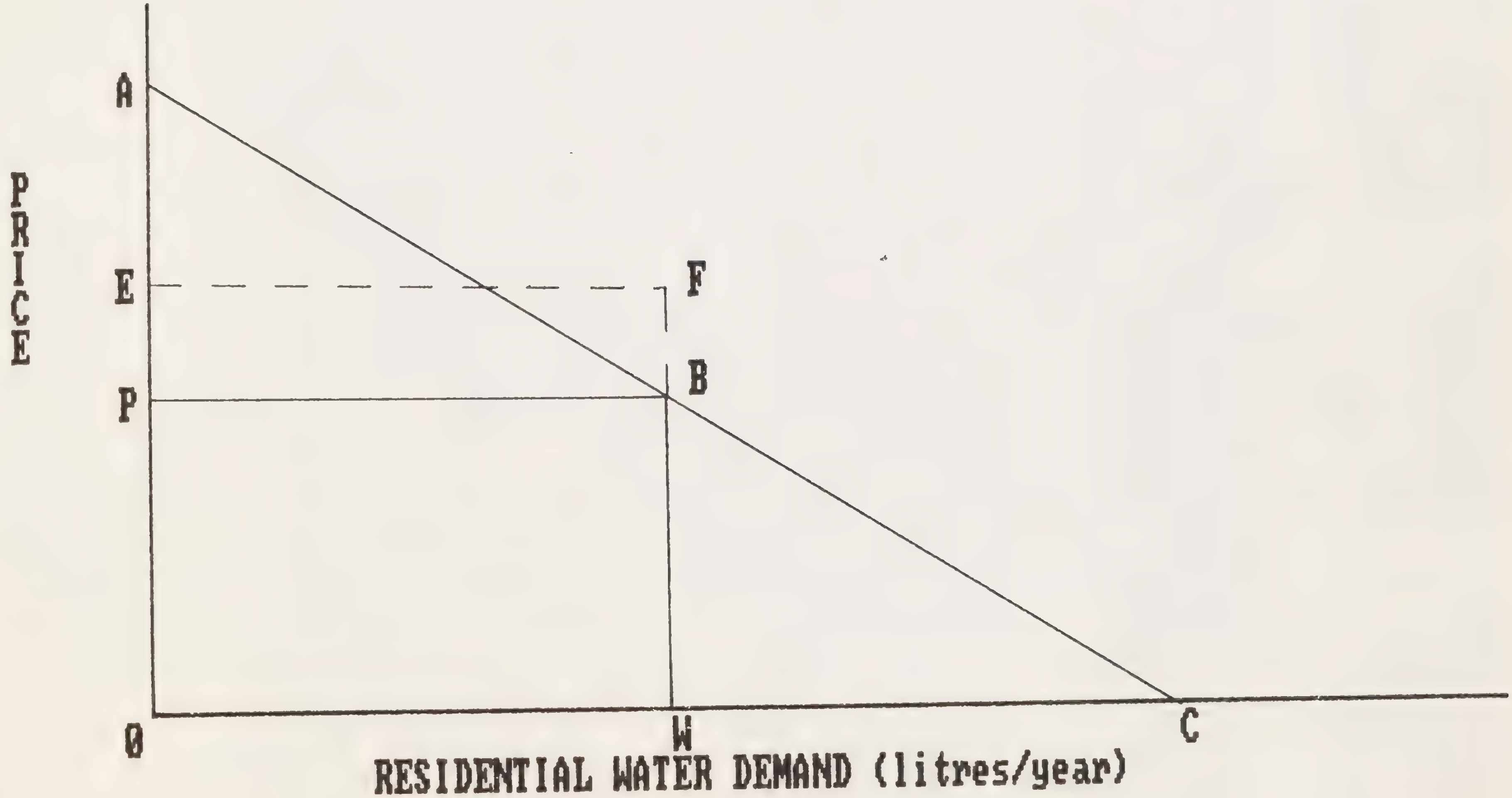
3.2.1 Direct Benefits

The simplest case is illustrated in figure 3.1. ABC is the demand curve for water in a particular use, say for residential consumption. If water is free, C litres will be demanded per year. Under certain conditions to be discussed below, the area under the demand curve, OAC, measures the amount consumers would be willing to pay for C litres of water and consequently the amount they would be willing to accept in exchange for giving up all their drinking water.

If water is supplied at a price of $P per litre, consumption is restricted to W litres. Total willingness to pay for this amount is OABW. Actual payments equal OPBW and the difference, ABP, represents the benefit that consumers receive from being able to purchase water at price P rather than do without it entirely. This area is called the net willingness to pay or <u>consumers' surplus</u>.

Total WTP for water (OABW) is the value of the delivered water to the consumer. If delivered water were not available, consumers would need to spend this amount on other goods and services to feel as well off as they did before. But in this case they would be able to redirect their previous expenditure of OPBW and therefore they would require an additional payment of only PAB dollars to fully compensate them for their loss. Therefore the net value of water to consumers is the consumers' surplus PAB.

FIGURE 3.1



We can divide total WTP and consumers' surplus by the quantity of water consumed, OW, to obtain an average value of water. The average gross value of water (OE in figure 3.1) exceeds the average net value (PE) by the price paid per litre (OP).

It is useful to distinguish between the value of the water delivered to the consumer and the value of "raw" water in the original watercourse. Labour, capital and other materials have to be applied to the raw water in order to treat it and deliver it to the consumer. The true cost of the delivered water is the quantity of goods and services which these resources could have provided if they were not dedicated to the production of delivered water.

If the price of delivered water is equal to the average cost of delivering it, then the average value of the raw water is equal to the average consumer surplus on the delivered water (PB). This is the amount (per litre of current water consumption) which would have to be paid to consumers to fully compensate them for the loss of access to water at price P.

If the supply of water is limited to W litres per year but there are no resource costs of providing it to consumers, then the average value of raw water equals the average WTP for delivered water. In general, the average value of raw water to society at large is equal to the difference between the average value of delivered water and the average cost of delivering it. If the price is above the average cost of delivery, then some of the benefits of water will accrue to the producers of delivered water and will appear as profits or wage payments above the returns these factors could obtain in other occupations.

The interest in calculating average values lies in the hope that they will provide some guidance in the allocation of scarce water resources. Of course the appropriate allocation of resources depends on the specific political, economic and ethical criteria used by the decision maker. A common criterion advocated by many economists is that resources should be allocated so as to exploit all opportunities for mutually advantageous trades. This is frequently expressed in the statement that water should be allocated to its highest valued use. In any other allocation, users with higher WTP could purchase water from those with lower WTP, leaving both parties better off.

On this criterion, the concepts of average WTP and average cost are appropriate for allocating large blocks of water between mutually exclusive uses, for example in choosing between devoting all the water in a river to residential rather than industrial use. When water can be shared, however, it should be allocated so that the marginal value of one additional litre should be the same for every user. This is because the relevant choice is not a total reallocation of water from one group of users to another but a small increase in water used by one group at the expense of some other. The marginal value of water is measured by the height of the demand curve, WB in figure 3.1. Clearly the marginal value of water is equal to the price paid by the user and our criterion thus suggests that we equate the price of water for all users. In fact, it is well established that this common price should equal the marginal cost of delivering the water.

To reiterate, the average value of raw water is a well defined concept equivalent to the difference between the average willingness to pay for delivered water and the average cost of delivery. In choices between mutually exclusive alternatives, water should be allocated to the users for whom water has the highest average value, subject to appropriate compensation for the original users. In choosing between uses in which marginal adjustments are possible, water should be allocated so that the marginal willingness to pay for water is the same in all uses.

3.2.2 Complications

We now consider a number of complications which arise in attempting to apply these concepts to the measurement of the economic value of water. These include the possibility that demand curves do not intersect the price axis, the effect of substitutes, the treatment of unobservable demand curves, and the valuation of water quality. Two further problems, the distinction between willingness to pay and willingness to accept compensation and the treatment of water in indirect uses are discussed in sections 3.2.3 and 3.2.4 respectively.

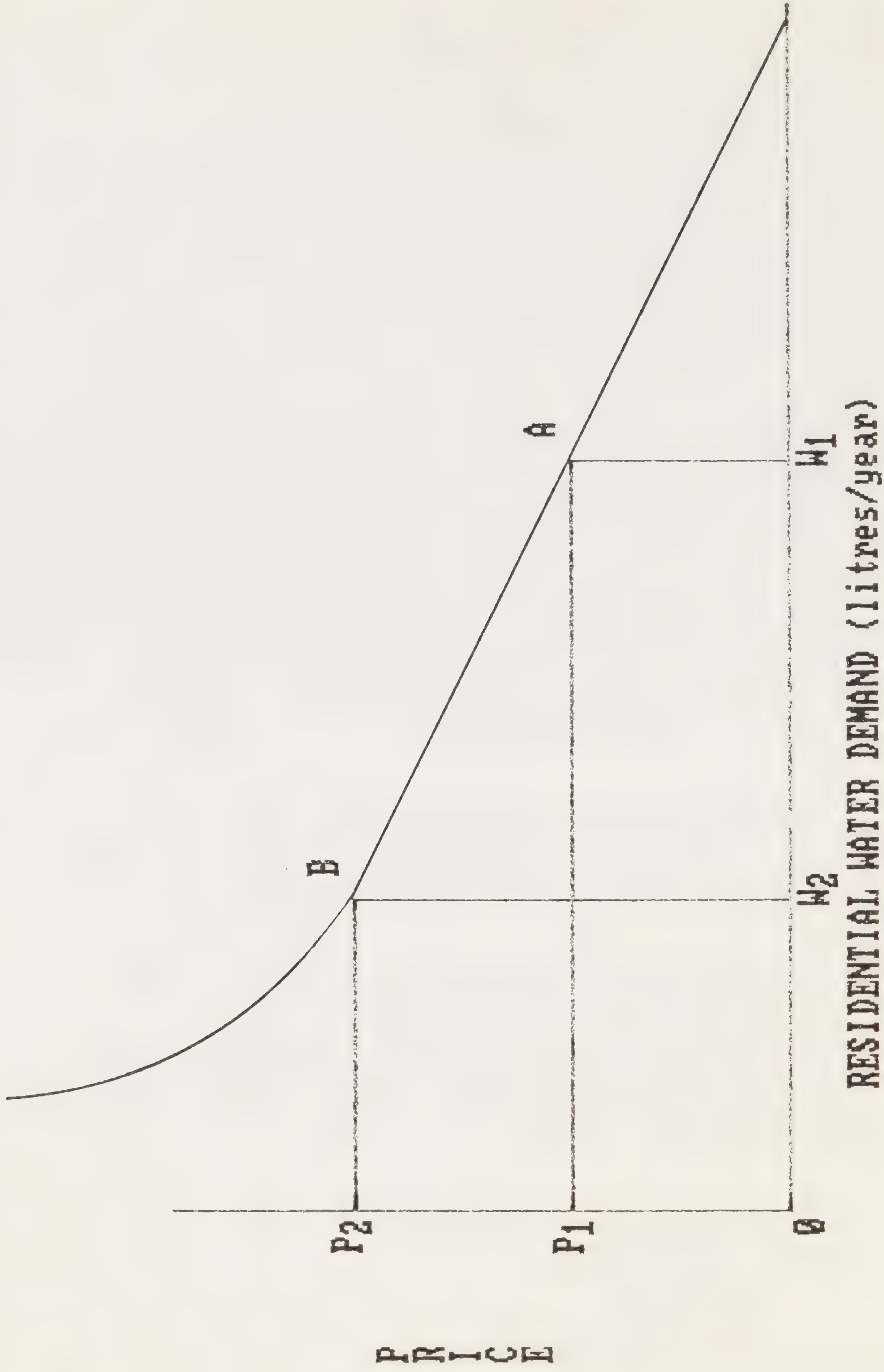
Water in some form is essential to life. Furthermore there may be some individuals who would be unwilling to trade their access to water for any price. These would include individuals who feel a religious or ethical responsibility for conserving the natural environment. This suggests that in some uses there is no price which would drive the demand for water to absolute zero. In this case, illustrated by figure 3.2, the area under the demand curve is infinite since there is no price intercept.

In this case both total and average WTP for water are infinite although marginal WTP is still well defined. We can, however, consider the willingness to pay for a large reduction in water consumption, say from W_1 to W_2. This could be accomplished by a rise in price from P_1 to P_2. The total WTP to avoid this reduction is W_1ABW_2 and the loss of consumers' surplus is P_1ABP_2.

Under these circumstances it is natural to define the average value of raw water as the lost consumer surplus divided by the reduction in raw water consumption and the the average gross value of delivered water over the range W_1W_2 as the total WTP, W_2BAW_1, divided by the quantity reduction, W_1W_2.

Now suppose a perfect substitute for the raw water is available. For example, surface water drawn from Lake Ontario might be replaced by groundwater or water piped in from Georgian Bay. Let P_1 be the price of delivered water from the original source and let P_2 be the price of delivered water from the next best alternative source. Under these circumstances, it is natural to define the average value of raw water from Lake Ontario as the loss in consumers' surplus, P_1ABP_2, divided by

FIGURE 3.2



the original level of raw water consumption from Lake Ontario. Under this definition, the total value of water in Lake Ontario for residential use can be recovered by multiplying the estimated average value by the consumption level.

If the elasticity of demand for delivered water is known, the loss in consumers' surplus caused by an increase of price can be directly computed. For a demand curve of constant elasticity n (with n<0), the formula is

$$(3.1)\ CS = p_0 q_0\ (t^{n+1} - 1)/(n+1)$$

where CS is consumers' surplus, p_0 and q_0 are original price and quantity respectively, and t is the ratio of the new price to old.

Notice that if the elasticity of demand is zero, the loss in CS becomes $p_0 q_0$ (t-1) or simply the percentage increase in price times the original expenditure. Also notice that the average loss in consumer surplus in this case is simply p_0 (t-1), the amount of the price increase.

Table 3.1 tabulates illustrative values of CS for differing price increases and elasticities. It also indicates by how much the true loss is overstated by the cost of the next best alternative. For example, if the alternative source of water raises costs by 30% and the elasticity of demand is -.5, the true loss in consumers' surplus is 28% of the original expenditure. This is 93.5% of the increased cost of supplying the original amount of water using the next best alternative.

Table 3.1 indicates that when demand is quite inelastic (say -n<.5) the effect of demand can be safely neglected for cost increases of up to 100% or more. However, when demand is as elastic as -3, the effect of cost distortions of as little as 30% will be seriously overstated unless the correct formula is used.

Table 3.1

CONSUMER SURPLUS LOSSES USING EXPONENTIAL DEMAND CURVES
(as fraction of expenditure at original prices)

Cost Increase	Elasticity -0.1	-0.5	-1	-1.5	-2	-3
10%	0.100	0.098	0.095	0.093	0.091	0.087
20%	0.198	0.191	0.182	0.174	0.167	0.153
30%	0.296	0.280	0.262	0.246	0.231	0.204
50%	0.489	0.449	0.405	0.367	0.333	0.278
70%	0.680	0.608	0.531	0.466	0.412	0.327
90%	0.869	0.757	0.642	0.549	0.474	0.361
110%	1.055	0.898	0.742	0.620	0.524	0.387

TRUE LOSS AS PERCENTAGE OF ESTIMATE WHEN ELASTICITY IS NEGLECTED

Cost Increase	Elasticity -0.1	-0.5	-1	-1.5	-2	-3
10%	99.5	97.6	95.3	93.1	90.9	86.8
20%	99.1	95.4	91.2	87.1	83.3	76.4
30%	98.6	93.5	87.5	82.0	76.9	68.0
50%	97.9	89.9	81.1	73.4	66.7	55.6
70%	97.2	86.8	75.8	66.6	58.8	46.7
90%	96.5	84.1	71.3	61.0	52.6	40.2
110%	95.9	81.7	67.4	56.4	47.6	35.1

Although the discussion so far has concerned perfect substitutes, it is important to note that the height and shape of the demand curve for water in any use depends crucially on the availablity and price of substitutes of any kind. In general the easier it is to substitute other water sources or activities for water from a given source, the more elastic will be the demand and the less will be the average value of the raw water in this use. Clearly estimates of the average value of water will depend heavily on the precise nature of the substitutes considered. These will normally vary widely from use to use and location to location. For this reason, a fully satisfactory estimate of the total value of water to Canada would require an immensely detailed specification of the alternative levels of water supply and quality assumed available under alternative circumstances and the substitutes which are assumed to exist.

3.2.3 Unobservable Demand Curves

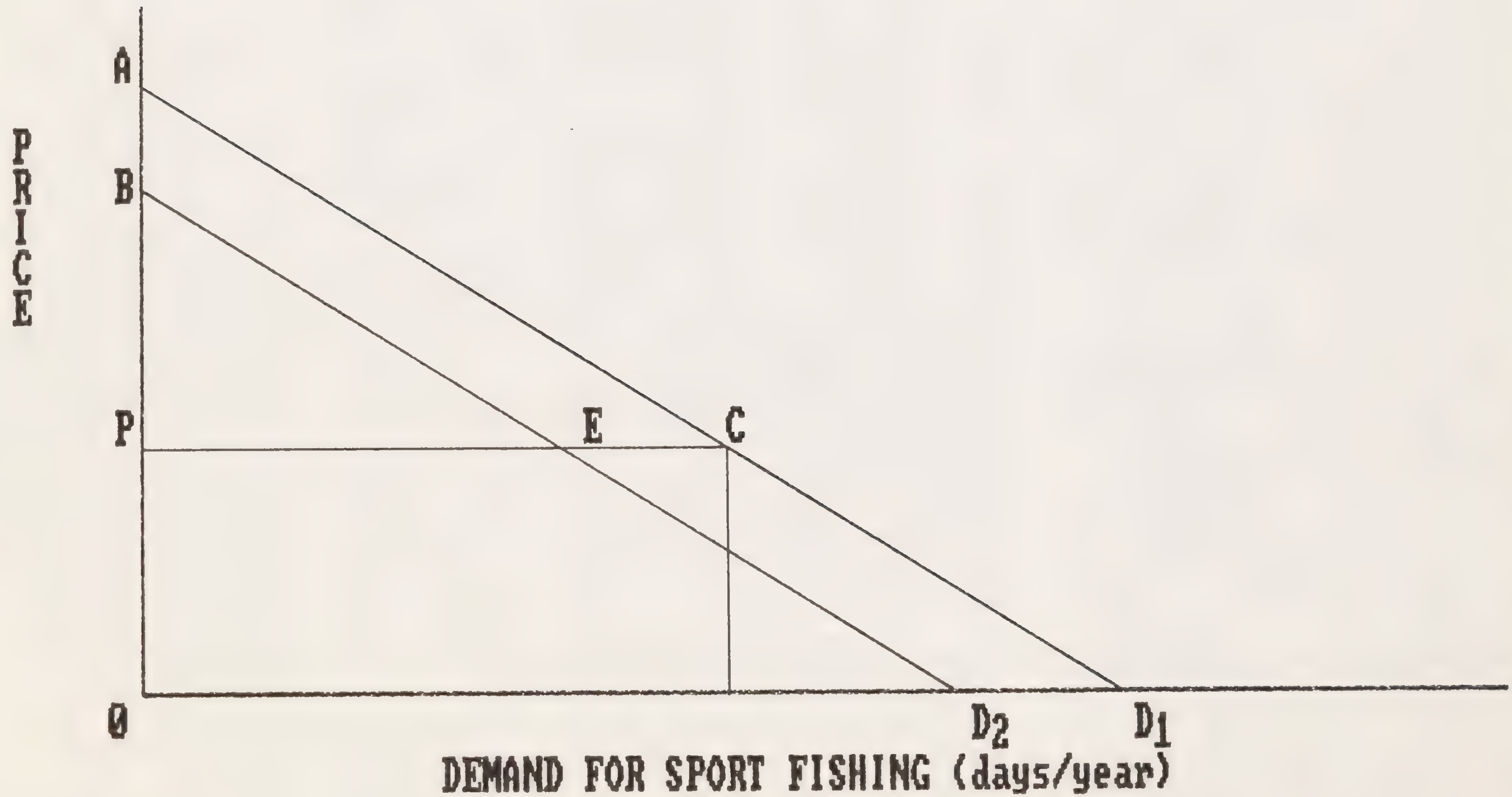
In many uses, especially those involving recreation, the services of water are not bought and sold in markets of any kind. Consequently it is impossible to estimate average values by directly estimating a demand curve for water in these uses. Fortunately, indirect methods can be employed to obtain information on willingness to pay.

In these methods, the willingness to pay for water is measured by the change in demand for a related activity such as recreational fishing. Figure 3.3 provides an example. In this figure, ACD_1 represents the demand for fishing-days in a particular area. It can be estimated using a number of techniques discussed in section 4. Consumers' surplus is PAC and average consumers' surplus per fishing day is easily computed.

Suppose first that some project is considered which would totally eliminate fishing in the area. Fishermen would be willing to pay up to PAC to maintain their right to fish, and so the value of the water is measured by this amount. If an estimate of average consumers' surplus per fishing day is available, the total value of the water can be easily computed by multiplying by the current number of fishing days.

Water Quality changes can be handled in a similar fashion. Suppose in figure 3.3 water quality declines to the point that high quality game fish can no longer be caught. The demand curve for fishing shifts inwards to BED_2 loss in consumers' surplus is ABEC. This can be expressed as an average per fishing day or per fish caught. Russell and Vaughan (1982) derive such estimates for the United States and multiply by the expected change in fishing days to estimate the national benefits to fishermen of water pollution control in the United States.

FIGURE 3.3



3.2.4 Payment vs. Compensation

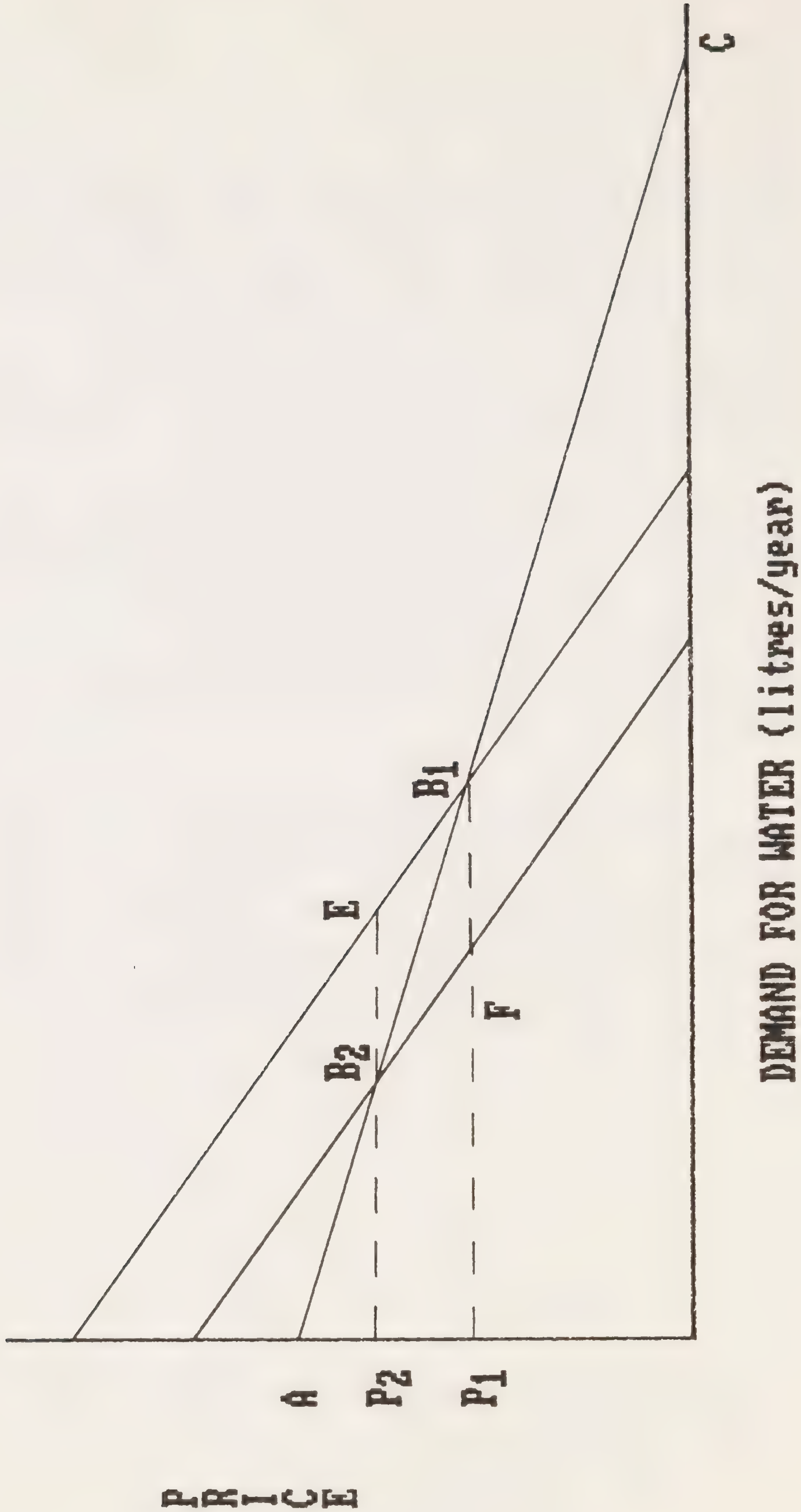
The previous analysis has assumed that the consumers' surplus measures both willingness to pay (WTP) for water and willingness to accept compensation in return for giving it up (WTA). This neglects the problem noted in section 3.1 that in some circumstances people might refuse to trade their rights for access to water while at the same time they would pay only a finite sum to recover those rights once lost.

A discrepancy between WTP and WTA can arise simply because of the income effects of a price change. Figure 3.4, based on Freeman (1978), illustrates the problem.

AB_2B_1C is the conventional demand curve for water. A rise in the price of water from P_1 to P_2 reduces the welfare of consumers. It is possible to draw "income-compensated" demand curves which show the quantity of water purchased at each price level when consumers' incomes are continually adjusted to keep their level of satisfaction constant. Two such curves are illustrated. Along B_1E satisfaction is at the original level corresponding to the low price, P_1, and along B_2F satisfaction is constant at the lower level corresponding to a higher price for water, P_2.

Strictly speaking, the amount consumers are willing to pay or accept in compensation should be calculated using the income compensated demand curves. If consumers currently have access to water at price P_1 they would require compensation of at least $P_2EB_1P_1$ voluntarily accept a price increase to P_2. If they are forced to pay to maintain the original price level their income has effectively been reduced and demand curve B_2F is relevant. Their WTP to prevent the price increase will only be PB_2FP_1. The consumers' surplus estimated above, $P_2B_2B_1P_1$ is a compromise between the two.

FIGURE 3.4



Willig (1976) has shown that under the normal assumptions made in economic theory the discrepancy among the three measures will be very small whenever expenditure on the commodity in question is a relatively small fraction of the consumers' total budgets. In fact, however, empirical estimates frequently show WTA exceeds WTP by substantial margins.[9] While some argue that such large discrepancies are the result of strategic behaviour on the part of survey respondents, there is some indication that this is not the full story. Work by Knetch and others shows an unaccountably large differential between WTP and WTA in experimental situations. A related phenomenon is the hostility provoked in questionnaire studies attempting to ascertain WTA while questions about WTP generate fewer objections (APIOS). This may be attributable to individuals feeling they have no right to sell the environmental amenities in question or it may be related to the fact that people appear generally to place higher values on avoiding losses than achieving gains.[10]

The discrepancy between WTP and WTA in matters concerning environmental losses may be central to understanding why some people reject the Cost-Benefit approach to decision making. Further discussion of this point is postponed to section 5.

3.2.5 Indirect Uses

In the preceding sections we analysed cases in which water provided direct satisfaction to consumers. In other cases, water provides utility indirectly as an input into the production of other goods. A prime example is provided by agriculture, where irrigation water is combined with other inputs to produce food.

Although the distinction between direct and indirect uses of water is essential in some contexts, the fact that we have already distinguished between raw and delivered water allows us to apply most of the analysis without much change. This is because, while delivered water was assumed to provide direct benefits, raw water in fact was treated as an input into the production of delivered water.

The main possibility to consider with respect to indirect uses is that most of the benefits of access to water may accrue to producers. Consider the case of agriculture, illustrated in figure 3.5. Line ABC is the demand curve for grain facing the farmers in question. It will be horizontal if farmers face a perfectly elastic demand curve for their crops. Although the market demand for most agricultural products is inelastic, the demand for the products of irrigated agriculture in a particular region may be very elastic in view of the fact that dry land agriculture and imports provide close substitutes for the products of irrigation.

Line DB represents the supply curve of grain from irrigable land in the absence of irrigation. Area ABD represents income to farmers above the opportunity cost of their inputs. This income is termed producers' surplus and it may appear as higher profits of farmers, higher wages for farm labour, or greater profits in businesses supplying inputs to farmers, or it may be capitalized into the price of farm land.

Now let irrigation water be provided. Yields increase, and the supply curve shifts outwards to EC. Producers' surplus has increased to ACE and the increase, area DBCE, is the increase in farm incomes due to the irrigation. This is the maximum amount that farmers would be willing to pay to obtain irrigation water for their land and consequently is the value of water in irrigation. The cost incurred in delivering the irrigation water should be deducted from this to obtain the value of raw water in the water course.

If farmers do not increase their other expenses when irrigation is made available, then their revenues will increase in the same proportion as the increase in physical yield. Since costs do not change, this will be their increase in profits and consequently their maximum WTP for the delivered irrigation water. Normally, however, the intensity of use of other inputs will increase on irrigated land and the increase in producers' surplus is overestimated by the increase in yield.

Figure 3.6 illustrates the somewhat more complicated case in which demand is not perfectly elastic. Under these circumstances irrigation leads to an outward shift in the supply curve from S_1 to S_2. In this case consumers gain from the fall in price from B to D. The increase in consumer surplus is BCFD. Producers' surplus changes from BCD to DFG. This change may be positive or negative depending on the elasticity of demand and the change in costs, if any, of the farmers. Sampath (1983) has derived explicit formulas for the change in producers', consumers', and total surplus under special assumptions. These are reported in section 4.

It may be simpler in this case to consider the gross willingness to pay for the increased output made available by irrigation. This is equal to area HCFI in figure 3.6. Regardless of the distribution of benefits, this is the total WTP for the extra produce. An upper bound on this amount is given by the expected increase in net yield multiplied by the original price level.

FIGURE 3.5

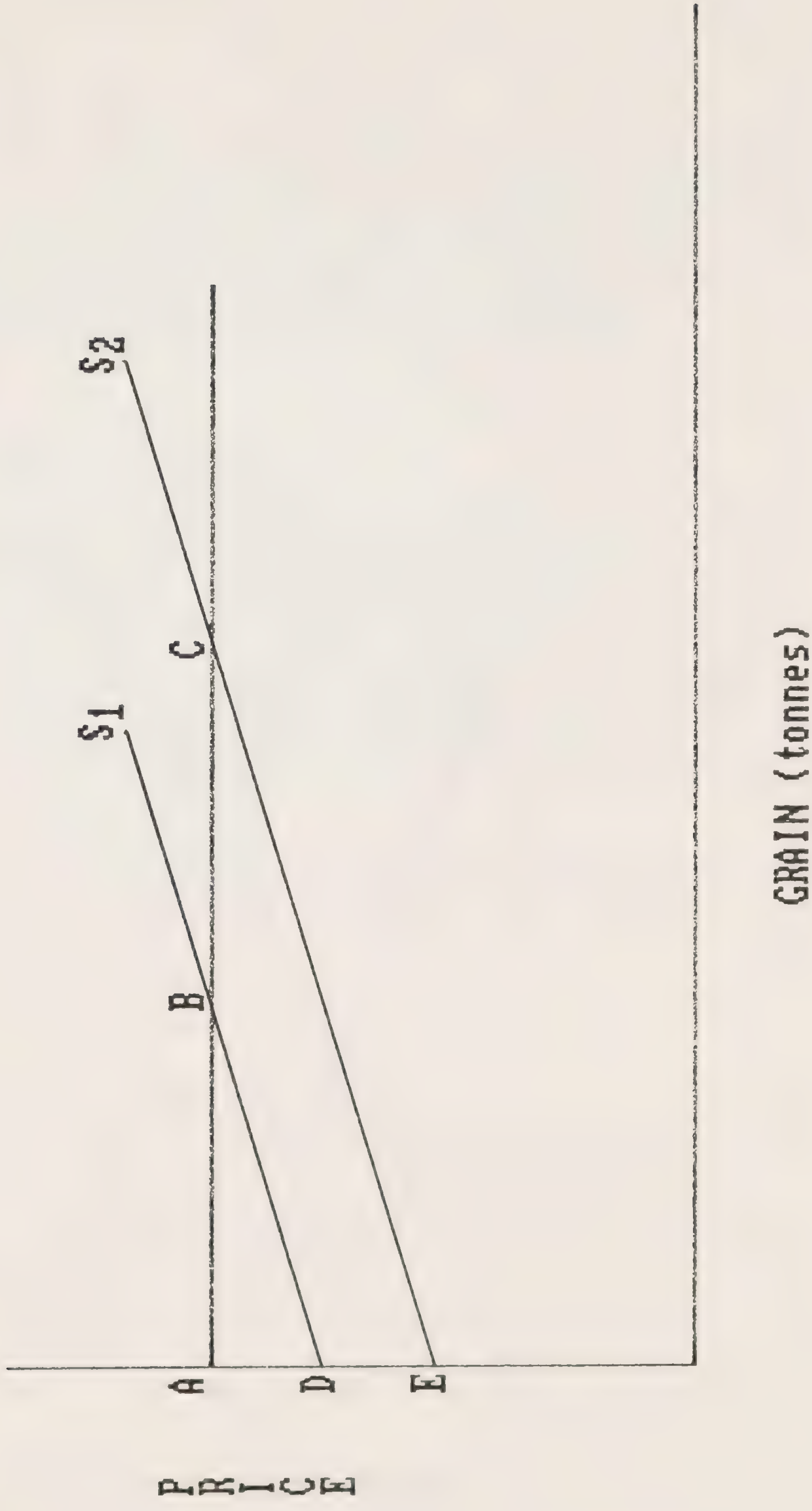
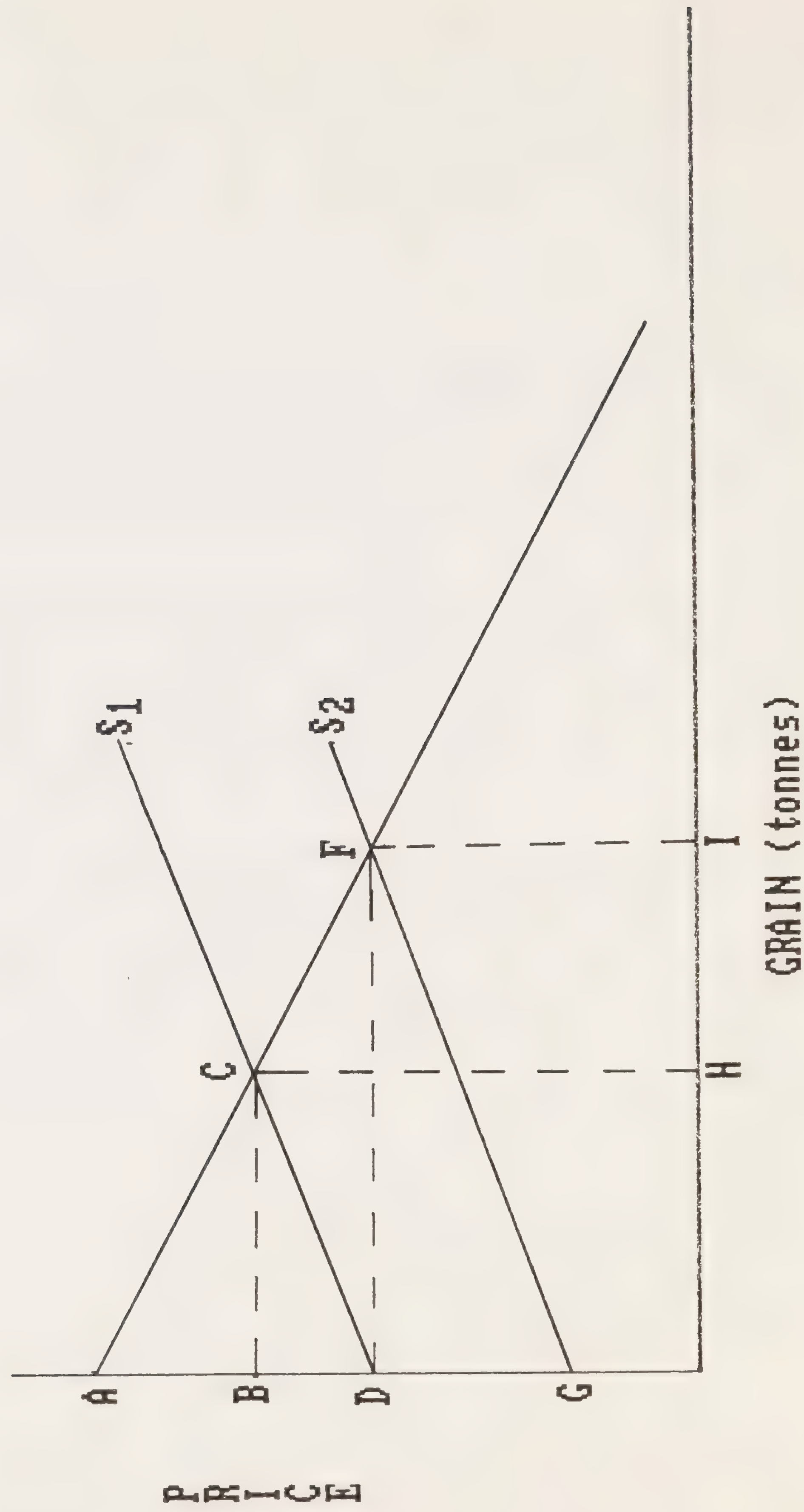


FIGURE 3.6



3.2.6 Summary

To conclude, the average net willingness to pay for raw water can be precisely defined and techniques can be found to approximate it in various situations. It will always depend upon the precise alternative to the current situation and on the presence and cost of substitutes. Unfortunately, there is no mechanical way to approach the problem -- most applications have special characteristics which force the analyst to choose a method of approximation which conforms to the theory and yet does not put excessive demands on the data available.

3.3 Approaches to measuring Value

In the previous section we defined the concept of average and total value of water. Many methods of estimating these values have been used, some of which were discussed above and others of which will be discussed in section 4. In this section, as required by the terms of reference for the study, we will comment specifically on three general approaches to estimating values: the value added approach, the cost of the next-best alternative, and willingness-to-pay. We also comment generally on some specific techniques of measuring willingness to pay. Our criterion will be consistency with the fundamental concepts of valuation discussed above.

In duscussing the benefits of water pollution abatement, Freeman (1978, 8) identifies several conditions which are necessary for any meaningful statement about values. Such statements must

i. use consistent terminology,

ii. clearly specify the reference points being compared,

iii. clearly indicate whether marginal or total benefits are being calculated and whether they are on a per capita or aggregate basis, and

iv. clearly specify the specific pollutants and sources being considered.

In addition any estimates of the benefits of water pollution control (and, similarly, the value of water) should

i. be derived by a method which allows them to be expressed in monetary units,

ii. be derived from individual behaviour and preferences,

iii. be related to changes in pollution levels or ambient quality, and

iv. be based on correctly specified theory.

Most attempts to measure the value of water fall into two categories: measures of economic activity and measures of economic surplus (see APIOS). The economic activity measures all have grave flaws as measures of value. The economic surplus measures all attempt to measure willingness to pay in one form or another. We shall examine each in turn.

3.3.1 Measures of Economic Activity

A common method of indicating the importance of an industry or activity is to report the level of economic activity associated with it. The indicator used may be value of shipments, value added (roughly equivalent to contribution to gross domestic product) or employment. Such measures were used in section 2 of this report.

Since we have defined the value of water as the amount users would be willing to pay to maintain their access to it, economic activity measures are inappropriate indicators of value simply because they do not attempt to measure willingness to pay.

For example, consider the value added in industries which use water intensively. This is roughly equivalent to the total incomes earned by the workers and owners of capital in the industry. It would be a valid measure of producers' willingness to pay to maintain access to water only if the absence of water would reduce factor incomes to zero.

There are two important reasons why factor incomes would not be driven to zero by the loss of water supplied to the industry. First, there are usually important ways to economize on the use of water by redesigning the production process. For example, water can be recirculated at the cost of increased operating costs and investment in cooling towers. Secondly, if the output of the industry in fact falls because of the rising price or reduced availability of water, the workers displaced will often be able to find employment in other industries and the owners of capital can redirect their investment. Accordingly, value added in the industry greatly overstates the loss which producers would incur if water were to become scarcer.

Similar considerations hold for total employment in a water based industry and the total value of output. Neither measures the gain to consumers or producers from access to water and neither measures the amount by which they would have to be compensated for a loss of water.

3.3.2 Measures of Economic Surplus

These measures have been highly developed in the US literature. However, the general proviso that willingness to pay to prevent the loss of water does not provide a fully satisfactory measure of the payment which would fully compensate for a loss must be borne in mind.

The methods may be grouped under two headings of direct (consumption) benefits of water and indirect (production) benefits. Under each head are several techniques which may be appropriate according to the circumstances. The cost of the next best alternative is among these. In all cases the ultimate aim is to estimate the variation in income which would fully compensate consumers for a change in the quantity or quality of water available.

The value of water in direct uses can be measured directly through surveys or indirectly through preferences revealed in market behaviour.(see Schulze, d'Arge and Brookshire, and Freeman).

In the survey method, people are asked directly what they would be willing to pay to prevent environmental damage or to obtain environmental improvements. Care is normally taken to provide respondents with relatively full information about the proposed change and to suggest a credible method of payment.

Schulze, d'Arge and Brookshire provide a good summary of the advantages and disadvantages of this method. A major advantage is that survey methods can be applied without the elaborate assumptions required by other methods. A number of sources of bias may be present, however. These include strategic bias on the part of respondents and bias induced by lack of information about the changes, lack of realism of the payment mechanism and the starting point of the questions. A further problem noted in the APIOS study is that questions attempting to gauge required compensation may be met with hostility. Finally, Freeman (1979, 1982) notes that even if their responses are unbiased, respondents have little incentive to provide accurate information. Nevertheless, the survey method appears to obtain results comparable to imputed market methods when applied to the same problems, and Schulze, d'Arge and Brookshire argue strongly for it.

Market based measures infer willingness-to-pay from observed behaviour. They include travel cost, cost of perfect substitute, weak complement and property value methods. In the travel cost method, a demand curve for a recreational site is deduced from the costs incurred by people travelling to it from various distances. This demand curve can then be used to estimate the consumers' surplus arising from a water-based recreational activity. The cost of perfect substitute method infers the willingness to pay for water from the cost of purchasing a perfect substitute, as discussed above. In the property value method, the benefits arising from proximity to a body of water are deduced from changes in the value of real property in the vicinity. Estimates using many of these methods are reported in section 4.

Most attempts to measure the value of water in indirect uses have focussed on the cheapest alternative means of production, as discussed in section 3.2.2 above. In this method, the value of water in production is estimated by the amount by which costs would increase in water was not available for this use. Examples include estimates of the rent derived from hydroelectricity in Canada which will be discussed in section 4.

The next best alternative method will overstate the value of water if the elasticity of demand for the product is ignored. The amount of this bias was discussed in section 3.2.2.

3.4 Conclusion

In this section, we have defined the value of water to be the quantity of other goods which Canadians would voluntarily accept in exchange for their right to use Canadian water. This is equivalent to the concept of benefit in Cost-Benefit Analysis and is approximated by consumers' willingness to pay for access to water. The average value of raw water is the difference between the average willingness to pay for delivered water and the average cost of delivery.

The average value of water is an appropriate guide when allocating large blocks of water among mutually exclusive uses. When water can be shared, however, it should be allocated so that the marginal value is the same in each use.

The concept of average value can be defined when demand curves do not intercept the vertical axis, when demand is unobservable, and when water is used indirectly by producers rather than consumers. In all cases, however, the exact nature of the alternative considered must be specified. The average value of water from a particular source and in a particular use will be lowest when substitutes sources of water or substitute activities are easily found.

Strictly speaking, the average value of water to those with access to it should be measured by the compensation those people are willing to accept. Frequently, however, it is measured by willingness-to-pay. There is a considerable body of opinion holding that willingness to pay may seriously underestimate the value of water in recreational and non-consumptive uses.

Measures of economic activity such as value added and employment are poor indicators of the value of water because they neglect the possibility of substitution. Measures of economic surplus derived from water, such as willingness to pay and consumers' surplus have a clearer theoretical basis. Consumers' surplus from access to water can be measured by surveys or by inference from market behaviour. The cost of the next best alternative overestimates the average value of water if the elasticity of demand for the product is ignored.

4 The Economic Value of Water

In this section we attempt to estimate the value of water to some groups of users in the Canadian economy. The value of water to these groups is equal to the benefit they receive from the present availablity of water. These estimates are highly tentative and incomplete and must be interpreted carefully in the light of the discussion of section 3. In particular it must be remembered that the total value of water in any current use cannot be defined without specifying a precise alternative to the present situation.

Section 4.1 reviews the method used to obtain the estimates. A distinction is made between direct and indirect benefits of water. Section 4.2 provides estimates of the value of water in a number of withdrawal uses, all of which affect individual welfare indirectly through the production of various products. Section 4.3 provides estimates of the value of water in a number of instream uses, some of which provide benefits to individuals directly.

4.1 Method

For the purpose of this section, we interpret the value of water in a given use as the benefit users receive from being able to use water from the given source rather than from the next best alternative source. In principle this alternative should be specified in the context of a specific project or policy which is being analysed. A weakness of the following estimates is that they are not based on such a careful analysis. In general, the alternative we consider is the complete withdrawal of water from its current use.

Ideally we would like to obtain three measures of value for each use: marginal willingness to pay, total willingness to pay and net willingness to pay (or consumers' surplus). Unfortunately, such complete information is not generally available.

Water can yield benefits to individuals directly, as in the pleasure obtained from swimming, or indirectly through its contribution to a product, such as electric power, which does yield utility directly. Even when water is consumed directly, it has often been processed or transported before reaching the consumer. In the estimates below, we attempt to measure the value of "raw" water, that is, water in the watercourse before treatment or transportation.

In estimating the value of water in indirect uses, it is useful to consider the producers and the consumers of the water based product separately. If the producers are deprived of their current source of water, their costs will rise. Part of this cost increase will be reflected in higher prices to consumers. The value of the water to consumers is the loss in consumers surplus which they suffer when the price is raised. The value of the water to producers is the loss in profits or other income which they suffer.

To estimate the value of water to consumers we need to know the current consumption of the water based commodity, its price, the percentage by which the price would increase and the elasticity of demand. When these are known, net willingness to pay can be computed according to the formula developed in section 3, namely

$$(4.1) \quad NWTP = p_0 q_0 (t^{n+1} - 1)/(n+1)$$

where $p_0 q_0$ are the initial price and quantity, t is the ratio of the new price to the old, and n is the elasticity of demand.

The marginal willingess to pay for water is the change in this expression as water availability is decreased by one unit, namely

$$(4.2) \quad MWTP = q^0 (dp/dw)$$

where w is the quantity of water. Thus the consumers' marginal net WTP for water is equal to the quantity of the water product purchased times the amount by which price would rise if water were restricted by one unit.

The producers' willingness to pay for the water is less easily calculated. It is equal to the reduction in economic profits (or producers'surplus) which would be caused by a reduction in the availability of water. The reduction in producers' surplus may be manifested in reduced profits, reduced wages, or reduced earnings of other factors of production.

If the price is not altered by the change in water availability, then the producers' willingness to pay is simply equal to the increase in costs that they would suffer. Otherwise, some of the increased costs will be offset by increased revenues. In the special case of a constant cost industry, no factor of production is earning more than its opportunity cost and the loss of producers' surplus is zero.

To summarize, to estimate the value of raw water to consumers we require information on the current price, quantity and cost of producing the water-based commodity or service, an estimate of the elasticity of demand for the product, and an estimate of the increase in price which would be caused by lack of access to water. Estimating the value to producers requires similar information.

In the following sections we provide rough estimates of the value of water in a number of uses. In general, we survey the available literature and statistical data to obtain information on current prices, quantities and costs for each use. Most prices and values have been converted to equivalent Canadian dollar values at 1984 prices, using the Gross National Expenditure implicit price index. We also report elasticities where available. Finally, we search the available literature for indications of the percentage increase in costs which would occur if access to water under current terms were lost.

This information allows us to compute an average net willingness to pay for water in each use. We then apply the average net willingness to pay to total quantities of water used by region to obtain estimates of the total willingness to pay for water in that use.

The above procedure is altered to fit the needs and data limitations encountered in discussing the various uses.

4.2 Withdrawal Uses

4.2.1 Municipal Uses

Table 4.1 presents the regional distribution of municpal water intake in 1981. The total intake of 2867 billion litres accounted for 14.65% of estimated withdrawals. Municipal water consumption, estimated at 15% of intake, accounted for 7.69% of the national total.[11] Raw water is an input into the production of treated water for domestic and commercial use and serves as a vehicle for transporting and assimilating discharged wastewater. Users are charged for water use through a combination of general taxes, metered water rates, and sewage charges.

The elasticity of demand for water in municipal uses has been estimated by a number of authors. In Canada, Marcello and Ingram (1981) obtained a price elasticity of -.31 in a cross sectional study of 56 Ontario municipalities. Sigurdson (1982) reports a price elasticity of -.8 derived from survey data on willingness to pay for water in Manitoba and Saskatchewan. Results from the United States and elsewhere are summarized in Hanke (1978). These range from extemely low (-.02 to -.28 estimated from time series data in Chicago) to quite high (-1.16 to -1.58 estimated in a cross sectional study of industrial water use in England).

Clear differences in demand elasticity have been found among differing water uses, with winter residential demand noticeably less elastic than summer demand, which includes lawn watering. For example, Howe (1982) estimates that US winter residential demand has a price elasticity of -.06 while summer demand is more elastic at -.57 in the east and -.43 in the west. Howe also suggests that recent studies which attempt to incorporate the effects of declining block rate structures consistently arrive at lower price elasticities than previous work.

Not many estimates of the cost of municipal water treatment were located. Kitchen (1975) reports average unit operating costs for water supply in 49 Canadian municipalities in 1971. Converted to 1984 price levels and metric units, these ranged from a low of $52.71 per million litres per year (North Vancouver) to a high of $238.71 (Richmond Hill), with a mean of $119.09. No capital costs were reported. Details are reported in Table 4.2.

Table 4.1

Municipal Water Use and Willingness to Pay by Region, 1981

	Intake (Gl/a)	Distribution	Average Cost ($/Ml)	Average WTP/Ml ($/Ml)	Total WTP (M$)
Atlantic	212.03	7.39%	540.68	100.35	21.28
Quebec	930.55	32.45%	540.68	100.35	93.38
Ontario	992.16	34.60%	540.68	100.35	99.56
Prairies	368.80	12.86%	540.68	100.35	37.01
B.C.	364.07	12.70%	540.68	100.35	36.53
Canada	2867.59	100.00%	540.68	100.35	287.76

Notes:
1 Gl = 1 million cubic metres
1 Ml = 1 thousand cubic metres = .8107 acre-feet

Source:
Water data from Environment Canada, Water Planning and Management Branch.
Average willingness to pay to prevent 20% price increase when demand elasticity is -.8 calculated from formula, section 4.1. (See text near end of section 4.2.1.)

Table 4.2

Average Cost of Municipal Water Supplies

No.	City	1971 C$ Mg/a	1984 C$ Mg/a	1984 C$ Ml/a
1	Kamloops	93.52	280.93	61.88
2	N.Vancouver	79.66	239.30	52.71
3	Penticton	115.44	346.78	76.38
4	Trail	118.32	355.43	78.29
5	Stratford	249.43	749.29	165.04
6	Vancouver	150.36	451.68	99.49
7	Calgary	136.28	409.39	90.17
8	Edmonton	204.01	612.85	134.99
9	Lethbridge	218.66	656.85	144.68
10	Prince Albert	272.31	818.02	180.18
11	Regina	284.90	855.84	188.51
12	Saskatoon	177.14	532.13	117.21
13	Prince Rupert	134.29	403.41	88.86
14	Bellevill	192.49	578.24	127.37
15	Brantford	268.04	805.19	177.36
16	Brockville	186.10	559.04	123.14
17	Chatham	270.87	813.69	179.23
18	Cobourg	158.47	476.04	104.86
19	Cornwall	144.05	432.73	95.31
20	Galt	140.99	423.53	93.29
21	Georgetown	238.07	715.16	157.52
22	Hamilton	127.80	383.91	84.56
23	Kingson	162.30	487.55	107.39
24	Kitchener	251.40	755.21	166.34
25	Niagara Falls	289.37	869.27	191.47
26	North Bay	196.91	591.52	130.29
27	Red Deer	326.36	980.39	215.94
28	Oshawa	231.40	695.13	153.11
29	Pembroke	152.60	458.41	100.97
30	Peterborough	169.85	510.23	112.39
31	Port Colborne	237.16	712.43	156.92
32	Preston	206.44	620.15	136.60
33	Richmond Hill	360.56	1083.12	238.57
34	Sarnia	106.83	320.92	70.69
35	Timmins	156.76	470.91	103.72
36	Truro	98.26	295.17	65.02
37	Guelph	191.96	576.65	127.01
38	Wallaceberg	247.04	742.11	163.46
39	Waterloo	203.73	612.00	134.80

Table 4.2
(continued)

Average Cost of Municipal Water Supplies

No.	City	1971 C$ Mg/a	1984 C$ Mg/a	1984 C$ Ml/a
40	Welland	255.41	767.25	169.00
41	Windsor	191.77	576.08	126.89
42	Newmarket	229.45	689.27	151.82
43	Cap de la Madelaine	163.98	492.60	108.50
44	Quebec City	87.18	261.89	57.68
45	Campbellton	150.70	452.70	99.71
46	Moncton	137.99	414.52	91.30
47	Amherst	168.94	507.50	111.78
48	Glace Bay	144.29	433.45	95.47
49	New Glasgow	99.42	298.66	65.78
	Average	179.99	540.68	119.09

Notes:
1 Mg/a = 1 million gallons per year.
1 Ml/a = 1 thousand cubic metres per year.
Implicit GNE Deflator (1971=100) for 3rd Q 1984 is 300.4

Source: Harry M. Kitchen,"A Statistical Analysis of an Open Municipal Water Provision" Urban Analysis 1977(4),

Hanke and Wentworth (1981) used an engineering cost function to compute the marginal cost of wastewater treatment in a typical United States community (see Table 4.3). Their estimate of US$ 0.57 per cubic metre per year (at 1979 prices) is equivalent to about C$984 per million litres per year at 1984 prices. Since there is clear evidence of economies of scale in wastewater treatment[12], average costs would be greater than this. Capital costs accounted for 94% of the total.

The public expenditure data reported in Table 2.11 imply an annual expenditure of approximately C$1092 per million litres of water supplied and treated annually, consisting of $689 per Ml/a on water supply and $402 per Ml/a on sewage (see Table 4.4). These figures include both operating and capital expenditure and could only be interpreted as average costs if the municipalities were all in a long run steady state where capital expenditures were equal to depreciation. They may serve, however, as some indication of the order of magnitude of these costs. It will be noted that average sewage expenditures are noticably less than the marginal cost estimated by Hanke and Wentworth. This could reflect the fact that many communities in Canada are not providing secondary treatment for their wastes.

At least two previous studies have attempted to measure the value of water in municipal uses. Young and Gray (1972) estimated the total willingness to pay for delivered water by assuming an elasticity of demand, a prevailing price, and a hypothetical reduction in quantity separately for residential lawn watering in the eastern US, residential lawn watering in the western US and in house winter use. The average willingness to pay per unit of water was calculated by dividing total WTP by the reduction in quantity. The "net value" or willingness to pay for raw water was computed by deducting the marginal price charged to users. The results, shown in Table 4.5, suggest an average WTP for raw water of between C$258 and C$550 per megalitre.

Sigurdson (1982) derived compensating variation measures explicitly from an estimated demand for water equation based on surveys of the WTP for water in 30 small communities in Manitoba and Saskatchewan with population ranging from 412 to 14,358. Since the logarithmic demand function which he estimated has no price intercept, he calculated the income variation required to compensate for a rise in price to some unspecified maximum value. Expressed as an average WTP in 1984 dollars, the results show a wide variation from $762 to $6,938 per megalitre, with an unweighted mean of $2430 (see Table 4.6)

Table 4.3

The Marginal Cost of Wastewater Treatment

Hanke and Wentworth (1981)	
Marginal Cost per kl/a, 1979 US$	0.57
Marginal Cost, 1984 C$/Ml.	845
Fraas and Munley (1984)	
Secondary Treatment (70% removal)	
1976 US$/lb of BOD removed	0.25
1984 C$/kg of BOD removed	1.02
1984 C$/Ml of sewage	204
Advanced Secondary (90% removal)	
1976 US$/lb of BOD removed	0.88
1984 C$/kg of BOD removed	3.58
1984 C$/Ml of sewage	717
Conversion Factors;	
Exchange Rate, 1976 (C$/US$)	0.9861
Exchange Rate, 1979 (C$/US$)	1.1715
GNE Price Deflator (1971=100), 1976	160.2
GNE Price Deflator (1971=100), 1979	202.7
GNE Price Deflator (1971=100), 1984	300.4
Kilograms per pound	0.454
Influent Concentration (mg BOD/l)	200

Table 4.4

Average Public Expenditures on Water Supply and Waste Treatment
Canada,1981

	Water Supply	Sewage	Total
Total Expenditure, 1981 (billion dollars)	1.643	0.960	2.603
Water Intake, 1981 (Ml/a)	2867.590	2867.590	2867.590
Average Expenditure 1981 (1981 C$/Ml)	572.955	334.628	907.583
Average Expenditure, 1981 (1984 C$/Ml)	689.290	402.572	1091.862

Source:
Computed from Table 2.11

Table 4.5

Reported Estimates of The Value of Municipal Water

	--Lawn Sprinkling-- East US	West US	Winter use
Young and Gray(1982)			
(1967 US$/'000 gallons)			
Average Gross WTP	0.37	0.56	0.66
Marginal Price	0.32	0.37	0.35
Average Net WTP	0.05	0.16	0.31
(1984 C$/Ml)			
Average Gross WTP	308	466	550
Marginal Price	266	308	291
Average Net WTP	42	133	258

Sigurdson(1982)	Average WTP for Water Saskatchewan and Manitoba
(1984 C$/Ml)	
High	6940
Low	760
Average	2430

Conversion Factors		
	1967 Exchange rate (C$/US$)	1.081081
	1967 GNE deflator	85.9
	1984 GNE deflator	300.4

Table 4.6

Consumer Surplus From Municipal Water in Saskatchewan and Manitoba

Province	Town	---Average CV----- (1981 C$)	(1984 C$)	Average ---Consumption--- '000 gal	kl	Average WTP ($/Ml)
Sask.	Swift Current	326.75	393.09	113.68	516.11	762
Man	Portage	293.15	352.67	30.65	139.15	2534
Man	Selkirk	126.36	152.02	19.51	88.58	1716
Man	Dauphin	259.83	312.59	56.26	255.42	1224
Sask	Estevan	393.29	473.15	56.94	258.51	1830
Man	Steinback	267.22	321.48	74.14	336.60	955
Sask	Melfort	392.40	472.07	48.21	218.87	2157
Man	Swan River	327.05	393.46	24.42	110.87	3549
Man	Virden	332.07	399.49	48.32	219.37	1821
Sask	Canora	416.62	501.21	33.13	150.41	3332
Sask	Moosomin	211.85	254.86	19.30	87.62	2909
Sask	Maple Creek	400.98	482.40	70.50	320.07	1507
Sask	Langham	436.43	525.04	49.78	226.00	2323
Sask	Kelvington	370.22	445.39	44.81	203.44	2189
Sask	Rovanville	330.02	397.03	26.80	121.67	3263
Sask	Ponteix	467.84	562.83	52.11	236.58	2379
Man	ND de Lourdes	286.53	344.71	36.38	165.17	2087
Sask	Balcarres	354.92	426.98	54.77	248.66	1717
Man	Treherene	147.06	176.92	15.65	71.05	2490
Sask	Elrose	515.31	619.94	79.41	360.52	1720
Sask	Cabri	539.21	648.69	50.12	227.54	2851
Sask	Blaine Lake	457.45	550.33	22.37	101.56	5419
Sask	Hague	445.31	535.73	50.63	229.86	2331
Sask	Lafleche	404.20	486.27	64.00	290.56	1674
Man	Minitonas	286.71	344.92	10.95	49.71	6938
Sask	Eatonia	275.47	331.40	36.46	165.53	2002
Sask	Raymore	373.52	449.36	38.45	174.56	2574
Sask	Springside	353.07	424.76	40.59	184.28	2305
Man	Wawenesa	341.42	410.74	46.47	210.97	1947
Man	Rapid City	332.33	399.81	36.75	166.85	2396
	Average	348.82	419.65	45.05	204.54	2430

Note: Price Level not reported, but assumed to be 1981
1981 GNE deflator 249.7
1984 GNE deflator 300.4

Source: computed from data in Sigurdson (1984)

To estimate the national willingness to pay for municipal water we require the percentage by which the cost and price of delivered water would rise if the current source of raw water were denied. Clearly, this depends on the reason why the current water source has become unavailable and on the availability of substitutes. This information will be specific to individual localities and events. For example if toxic chemicals made the water of Lake Ontario unfit for drinking, substitutes might be found by recourse to ground water, piping water from Georgian Bay or by discovering and implementing methods for treating the water. Each possibility would lead to a different increase in cost. Similarily, if the municipalities discharging raw sewage to the St. Lawrence River were to be denied this service, the cost of municipal water would rise by the average treatment cost of sewage, which as we have seen may be of the order of $1000 per million litres.

A detailed investigation of these possibilities in advance of specific deveopments would be extremely time consuming and is certainly beyond the scope of this paper. Nevertheless, a crude estimate of the order of magnitude of the effects can be derived from Kitchen's (1977, 128) observation that a change of source from surface to groundwater led to a $33 increase (18.4%) in average operating costs in his sample of Canadian municipalities. This suggests that we consider cost increases of the order of 20%. Assuming that price equals average operating cost and using equation (4.1) with an assumed elasticity of -.8, the net willingness to pay to avoid a cost increase of 20% would be 18.56% of the original value of the delivered water.

Table 4.1 reports the result of this calculation. If it were applicable to all municipal water in Canada, the total willingness to pay would be of the order of $288 million dollars.

The Sigurdson data imply a much higher value of municipal water. Applying his mean estimate of $2,430 per million litres yields a national net WTP of $6,968 million per year. (See Table 4.21)

4.2.2 Agricultural Uses

The major use of water in agriculture is for irrigation. Table 4.7 reports the distribution of agricultural water use for 1980. The vast majority is used in the western provinces, reflecting the importance of irrigation in the Prairie Provinces and in B.C. According to the Alberta Irrigation Projects Association (1984a, 1-3), a cost-sharing formula developed during the 1960's allocates 86 percent of the cost of irrigation activities to the provincial government and 14 percent to users. Irrigable land amounts to more than a million acres in Alberta alone, with 74% being sprinkled.

The characteristics of irrigated agriculture in Western Canada are well summarized by Veeman (1984). In particular, he notes that in southern Alberta irrigation water is not metered but that irrigators pay a flat fee of about $10 per acre.

A rough estimate of the rate of water use per hectare of irrigated land can be obtained by dividing total western water consumption (2717.8 Gl/a) by the irrigated acreage reported for western Canada in the Census of Agriculture (557292 hectares or 1,377,098 acres). The resulting coefficient is 1.974 Ml (thousand cubic metres) per acre (see Table 4.8). No estimate of the cost of providing irrigation in Canada appears in the recent published literature. The Alberta Irrigation Projects Association (1984b, 2.4) forecasts a total capital expenditure of 561 million 1982 dollars on irrigation projects over the period 1985-89. Roughly 150 million of this represents purchase of irrigation equipment. This is expected to yield an increase of some 133,300 to 175,000 acres of irrigable land and a total increase of some 5.4% in crop yields.

Combining the estimated capital cost per acre with the rate of water use yields an estimated capital cost of approximately $1388 per megalitre of delivered irrigation water. At a capital recovery factor of 10% this would amount to an annual cost of $139 per Ml or roughly $171 per acrefoot (see Table 4.8). This must be an overestimate, since it includes rehabilitation expenditure which does not add to irrigated acreage. Veeman (1984,58) reports estimates of $352-880 US dollars (at 1977 prices) per acre-foot for inter-basin transfers of water to the Ogalla Reservoir.

Table 4.7

Water Consumption in Agriculture by Region, Canada, 1980

REGION	---Consumption--- (Gl/a)	Percent	---Gross WTP---- Average ($/Ml)	Total (M$)
Atlantic	24.82	0.82	36	0.9
Quebec	30.66	1.01	36	1.1
Ontario	254.77	8.41	36	9.2
Prairies	2145.47	70.85	36	77.2
BC	572.32	18.90	36	20.6
Canada	3028.04	100.00	36	109.0

Source: Canada Water Year Book, 1981-82, and text.

Table 4.8

Calculation of the Approximate Marginal Cost of Irrigation Water

Estimated Capital Expenditure on Irrigation 1985-89 (AIPAb, 2.4) ($ million)	561
less Private expenditure on Irr. Equipment (AIPAb, fig. 2.2) ($ million)	150
Net Expenditure on Water Delivery ($ million)	411
Addition to Irrigated Acreage(thousand acres)	150
Capital Expenditure per acre ($ thousand)	2.740

Calculation of Average Water Use

Agricultural Water Consumpt(Environment Canada)	
Prairies	2145.47
BC	572.32
Total	2717.79
Irrigated Acreage (Veeman, p 24)	
Acres	1377098
ha	557292
Average Water Use	
kl/acre	1973.563
kl/ha	4876.779

Capital Expenditure per acre		Capital Charge per year at 10%	
$/acre	2740	$/acre	274
$/Ml	1388	$/Ml	139
$/acre-ft	1713	$/acre-ft	171

Conversion Factors

Sq Ft/acre	43560
cu.ft/acre-foot	43560
ft./metre	3.280833
cu.ft./cu. metre	35.31445
cu.m/ acre-ft	1233.489

Table 4.9

Alternative Estimate of Irrigation Water Benefits

Irrigated Agriculture Receipts, Alberta (AIPAb, 4.25) (million $)	672.4385
Irrigated Area (acres)	973519
Water Consumption (estimated) at 1973.563 kl/acre	1921.301 Gl/a
Receipts per unit of irrigation water	0.349991 M$/Gl
Total irrigation use, Canada	3028.04 Gl/a
Estimated Receipts	1059.787 M$/a
Increase in Yield at 5.4%	
per Ml of irrigation	18.89952 $/Ml
total willingness to pay	57.22852 M$/a

The elasticity of demand for irrigation water has been estimated in the context of regional programming models. The results depend critically on the treatment of the response of demand to price increases. In a quadratic programming study of California's Central Valley, Howitt, Watson and Adams (1980) found arc elasticities of -1.5 and -.46 in the price ranges of US$25-35 per acre-foot and US$35-45 per acre-foot respectively (at 1977 prices). These values indicate substantially greater elasticity than estimates derived from linear programming models which, in effect, assume perfectly inelastic demand for agricultural produce.

A number of previous studies have estimated the marginal value of irrigation water. Young and Gray (1972, 100-155) review many early studies. Most of these computed the increase in net income of irrigated farms and divided by water use to obtain an average willingness to pay. Values generally lay in the range of $5 to $25 per acre-foot. This is roughly equivalent to C$45 per acre-foot at 1984 prices. Young and Gray stress that these apply only to diversion from existing uses or the opening of new land. The marginal value of extra water on already irrigated land would seldom exceed $5 per acre-foot because it is generally devoted to lower valued crops.

Veeman (1984, 58) cites American studies indicating a marginal value product of up to US$44 per acre-foot of irrigation water in the Northern and Central Ogalla subregions of the High Plains (1977 prices).

Unfortunately, no similar estimates for Canada have been reported. The Alberta Irrigation Projects Association (AIPA, 1984b, ch 7) reports two estimates of the economic impact of irrigation in Alberta, but neither provides a measure of willingness to pay which could be compared with the cost of providing irrigation water.

The AIPA study is based on an input-output model of the Alberta economy. Such a model is capable of calculating gross provincial product by industry for any specified pattern of demand for final goods and services. The AIPA study calculated that, in the absence of irrigation, Alberta's gross provincial product would fall by 2.6%. ($3,027 million dollars at 1981 prices). This figure was computed by adjusting the input-output coefficients to reflect dryland agricultural technology and by reducing the final demand vector to reflect the absence of irrigated products (p. 6.2). Apparently, no upward adjustment was made in the vector of final demands to reflect the production of the resources which would be released from irrigated agriculture. This is equivalent to assuming that there would be no substitution of dryland produce for irrigated produce in provincial consumption and no increase in exports of dryland products. Such an extreme assumption will clearly overstate the contribution of irrigated agriculture to the provincial economy and hence the willingness to pay for irrigation.

The AIPA study also reports that continuing expenditures on irrigation for the period 1985-1989 would generate benefits of $415 million (1981) dollars in increased GDP in Alberta and the rest of Canada. Once again, this cannot be considered a measure of the willingness to pay for irrigation since the calculation does not consider the increase in GDP which would occur if the same investment were made in some other activity.

We conclude that, based on the American studies, the average willingess to pay for irrigation water in Canada is unlikely to exceed $45 per acre-foot or $36 per megalitre (thousand cubic metres). We repeat the provisos of Young and Gray that the true willingness to pay will vary widely from crop to crop and probably from locality to locality. In addition, under the current pricing structure the marginal willingness to pay for irrigation water is probably close to zero.

Applying a unit willingness to pay of $36/Ml to annual consumption yields a national average willingness to pay of 109 million dollars per annum at 1984 prices. As usual, the reader is asked to handle this figure with extreme caution. Note that this is a gross willingness to pay for delivered water.

As a check on this estimate, recall that the willingness to pay for irrigation water can be approximated by the value of the increased yield at the original prices. The AIPA study estimated the increase in yield from the continuing rehabilitation program to be 5.4%. By assuming that water intake is proportional to irrigated acreage in Western Canada, we can estimate Alberta's water intake for irrigation at 1921 Gl/a. Receipts from irrigated agriculture in Alberta were estimated by AIPA at 672.4 million 1981 dollars. Thus average receipts were roughly .35 million dollars per Gl and the increased yield amounted to approximately 19 dollars per Ml (about $23 per acre-foot). Applying this to total irrigation use in Canada yields 57.2 million dollars. This is a measure of gross willingness to pay for the degree of irrigation improvement currently being undertaken in Alberta. We would expect the total WTP for this increment to irrigation to be less than the total WTP for current irrigation levels, and so the result is consistent with that of the previous paragraph.

Finally, we note that all the previous estimates were of the gross willingness to pay for delivered water. The value of "raw water" for agricultural use will be gross willingess to pay less the costs of delivery. Since these costs appear to be substantially greater than $45 per acre-foot, the net value of raw water in agricultural uses is probably negative. This is consistent with the comments of Veeman (1984) and other authors.

4.2.3 Thermal Power Cooling

Cooling water for thermal power generation constitutes about half of total water withdrawals in Canada and almost 6% of consumption. Table 4.10 indicates that Ontario accounts for more than three quarters of withdrawals for this purpose, but that consumption is concentrated in the prairie provinces.

Cooling water for thermal power plants is normally withdrawn directly from the water course, usually the Great Lakes in Ontario. Consequently, the only price facing the utilities is the cost of physically bringing the water into the plant.

The gross intake of cooling water can be reduced by increasing the percentage of water recirculated within the plant. This requires additional investment in cooling tower and related equipment. The cost of recirculating water imposes an upper limit on utilities' willingness to pay for fresh water. Young and Gray (1972) used this fact to impute an average value of approximately US$3 per acre foot (at 1965 prices). This is equivalent to C$10.83 per acre-foot or $8.784 per Ml.

No recent estimates of the cost of recirculation were found in the literature consulted for this study. Tran and Smith (1983) estimated a mulitple output cost function for steam electric power generation for sample of US power plants built between 1948 and 1968 in which air and water residuals were treated as outputs. Waste heat discharges were proxied by the quantity of water discharge times the "difference in maximum temperatures" [presumably of the effluent and receiving water course]. Unfortunately, Tran and Smith do not report the elasticity of cost with respect to heat discharges. The linear terms of their equation imply that it ranges from approximately -.1 to .2, depending on the vintage of the capital stock. The negative term indicates that reduction in heat is associated with <u>redutions</u> in cost for some vintages while in the newest plants, a 50% reduction of heat discharge would imply a 10% increase in total cost.

Applying an average willingness to pay of $8.784/Ml to total intake yields a total WTP for water of about 169 million Canadian dollars (at 1984 prices). The regional distribution of these benefits are reported in Table 4.10.

It must be emphasized that these estimates are only a crude approximation to the increase in cost that would occur if all utilities were forced to recirculate cooling water. They represent an average net WTP for water under these circumstances. Since most cooling water is discharged to the Great Lakes where restrictions on heat discharge or water supply are very unlikely to occur, they probably overstate the true value of the water considerably. The marginal willingness to pay for cooling water in eastern Canada is probably close to zero.

Table 4.10

Thermal Power Use and Willingness to Pay, By Region

	Intake (Gl/a)	Dist.	Cons. (Gl/a)	Dist.	Est. Value of intake (M$)
Atlantic	1836.74	9.87%	40.71	29.33%	16.13
Quebec	307.83	1.65%	4.08	2.94%	2.70
Ontario	14257.99	76.62%	6.64	4.78%	125.24
Prairies	1846.49	9.92%	69.38	49.99%	16.22
B.C.	359.58	1.93%	17.97	12.95%	3.16
Total of above	18608.63	100.00%	138.78	100.00%	163.46
Canada	19280.83		168.24		169.36

Source: Quantities from Environment Canada, Inland Waters Directorate. Note that the sum of regional uses is less than the totals for Canada reported in the original data.

Note:
Quantities are for 1981. Values are at 1984 prices assuming average net willingness to pay of \$8.784/Ml. (see Table 4.11)

4.2.4 Manufacturing Uses

It was established in section 2 that water intake in manufacturing is highly concentrated. The top 5 water using manufacturing industries account for over 96% of manufacturing water use and 25.32% percent of all identified water uses. These are paper products (7.77% of total identified water intake), chemical products (7.65%), primary metals (7.29%) petroleum products (1.51%) and food processing (1.15%). The average willingness to pay for water will vary among them and from plant to plant within the industry depending upon the specific technology employed and the alternatives available to the current use of water.

Industrial water use in Alberta and Saskatchewan has been discussed in two recent papers. Erxleben and Hoyes (1983) discuss water management and data collection in Alberta and discuss trends in water use by industry. They find an increase in water intake by mining and manufacturing industries which is off set by declines in cooling water for power generation. Their data indicate that recirculated water accounts for almost 80% of gross water usage in the province. No attempt was made to estimate a value for water.

Kulshreshtha (1983) discusses the implications of water demand for industrial development in Saskatchewan. He considers the value of water in general terms, suggesting only that the elasticity of industrial demand for water will lie between inelastic residential demand and more elastic irrigation demand and that industries with high water use coefficients are likely to have inelastic demands for water. This last is a contentious point, for those industries are precisely those for which water conservation would yield great cost savings if prices were to rise. No attempt is made to estimate the value of industrial water quantitatively, although income multipliers for selected water using industries are reported.

Young and Gray (1972) provide illustrative examples of willingness to pay for water in the five most water intensive industries (see Table 4.11). These were derived from studies which generally attempted to measure the extra cost of recycling water to reduce fresh water intake.

Table 4.11

Estimates of Recycling Costs for Selected Industrial Water Uses

		1965 US$ /acre-ft	1984 C$ /acre-ft	1984 C$ /Ml
Cooling Uses:				
thermal power	median	2.639	10.83	8.78
beet sugar	low	7.82	32.11	26.03
	high	8.96	36.79	29.82
petroleum		5.572	22.88	18.55
Process Uses:				
steel	low	4.89	20.08	16.28
	high	13.03	53.50	43.37
minerals	low	3.26	13.38	10.85
	high	6.52	26.77	86.74
paper		26.06	106.99	86.74
sugar beets		37.15	152.52	123.65
chemicals		22.81	93.65	75.92

Source: Young and Gray (1972, Table 4).

Conversion Factors:
US dolloar exchange rate (1965) 1.08108108
GNE deflator (1967) 79.1
GNE deflator (1984, Q2) 300.4
cu. metres (kl) per acre-ft. 1233.489

The chief characteristics of these estimates are their range and their anecdotal character. Most were made from engineering data for specific manufacturing plants in specific locations. The range of estimates is dramatically shown by the willingness to pay for steel, where the high estimate of $53.50 per acre-foot is more than 2.5 times the low estimate of $20.08. In general, the willingness to pay for process water is considerably greater than the willingness to pay for cooling water. This is consistent with higher quality requirements for process water.

Applying these coefficients to the water intake data yields the willingness to pay estimates reported in Table 4.12. Total net WTP for water on this measure would be about $613 million per year for Canada as a whole. Once again, the reader is cautioned that such an estimate may be of very little value, since it neglects differences among plants and regions. In particular, recirculation may not be the relevant alternative for many users since a great deal of water is already recirculated in Alberta (see above) and probably elsewhere.

Table 4.12

Industrial Water Uses and Willingness to Pay

	--Water Intake---		-----Net WTP----	
	(Gl/a)	Distri-bution	Average ($/Ml)	Total (M$)
Paper and Allied				
Atlantic	335.70	11.6%	86.74	29.12
Quebec	1008.25	34.8%	86.74	87.46
Ontario	619.54	21.4%	86.74	53.74
Prairies	118.19	4.1%	86.74	10.25
B.C.	817.68	28.2%	86.74	70.93
Canada	2899.35	100.0%	86.74	251.49
Chemical Products				
Atlantic	24.37	0.9%	75.92	1.85
Quebec	721.82	25.3%	75.92	54.80
Ontario	1901.02	66.6%	75.92	144.33
Prairies	125.6	4.4%	75.92	9.54
B.C.	80.45	2.8%	75.92	6.11
Canada	2853.27	100.0%	75.92	216.63
Primary Metals				
Atlantic	114.47	4.2%	29.82	3.41
Quebec	267.77	9.8%	29.82	7.99
Ontario	1159.57	42.7%	29.82	34.58
Prairies	66.41	2.4%	29.82	1.98
B.C.	1110.37	40.8%	29.82	33.11
Canada	2718.60	100.0%	29.82	81.08
Petroleum Products				
Atlantic	64.16	11.4%	18.55	1.19
Quebec	83.1	14.8%	18.55	1.54
Ontario	330.09	58.6%	18.55	6.12
Prairies	19.55	3.5%	18.55	0.36
B.C.	66.16	11.8%	18.55	1.23
Canada	563.07	100.0%	18.55	10.44
Food and Beverages				
Atlantic	83.98	19.5%	123.65	10.38
Quebec	143.52	33.4%	123.65	17.75
Ontario	127.37	29.6%	123.65	15.75
Prairies	40.33	9.4%	123.65	4.99
B.C.	34.64	8.1%	123.65	4.28
Canada	429.84	100.0%	123.65	53.15

Table 4.12
(continued)

Industrial Water Uses and Willingness to Pay

	--Water Intake---		-----Net WTP----	
	(Gl/a)	Distri- bution	Average ($/Ml)	Total (M$)
Summary, Canada				
Paper Products	2899.35	30.6%	86.74	251.49
Chemicals	2853.27	30.2%	75.92	216.63
Primary Metals	2718.60	28.7%	29.82	81.08
Petroleum	563.07	6.0%	18.55	10.44
Food & Beverage	429.84	4.5%	123.65	53.15
Total	9464.13	100.0%		612.79

Source:
Water Data from Environment Canada, Inland Waters Directorate
Average value data derived from Young and Gray (1972) adjusted

4.3 Instream Uses

In this section we consider the value of instream uses of water. We have detailed information concerning water use for hydroelectric power generation, recreation and waste assimilation. Other instream uses will be dealt with briefly here and at more length in section 5.

4.3.1 Hydroelectricity

Hydroelectric power generation is the most obvious instream use of water. Table 4.12 summarizes hydroelectric power production in Canada for 1979 and 1983. Hydroelectricity accounts for two-thirds of all electric power generation in the country. Quebec and British Columbia rely almost exclusively on hydro and Quebec alone accounted for over 40% of total Canadian hydroelectric power generation in 1983.

Hydroelectric power generation confers benefits on Canadians indirectly through lower prices for electric power and the products produced with it. Without it, Canadians would have to rely on power generated from higher cost thermal generation, both conventional and nuclear.

The value of Canada's hydroelectric power resources can be measured by reduction in power generation costs which they allow. In the context of hydroelectric power, this cost saving is usually termed rent. Fortunately, two recent studies by Bernard, Bridges and Scott (1982) and Zuker and Jenkins (1984) have attempted to estimate the amount of these rents.

Both studies calculate the rent to hydroelectricity by comparing the cost of generating electric power in a mixed thermal-hydraulic system with the cost of an all thermal system. All thermal systems were designed for BC, Manitoba, Ontario and Quebec (including Churchill Falls in Newfoundland). The rent per kWh was calculated as the difference in average cost per kWh. Total rents were then calculated by multiplying total hydroelectric production by the estimated unit rent. Bernard, Bridges and Scott computed the true willingness to pay by allowing for the elasticity of demand while Zuker and Jenkins did not. The difference is not important except in the case of British Columbia.

Table 4.13

Generation of Electricity, Canada, 1979 and 1983
(Utilities and Industrial Sources)

	1979			1983		
	Hydro	Pct. of Total		Hydro	Pct. of Total	
	TWh	Hydro	Province	TWh	Hydro	Province
Nfld	42.228	17.36%	0.968	39.388	14.96%	98.49%
PEI	0.000	0.00%	0.000	0.000	0.00%	0.00%
Nova Scotia	1.176	0.48%	0.190	0.995	0.38%	16.16%
New Brunswick	3.136	1.29%	0.340	3.090	1.17%	26.67%
Quebec	88.514	36.40%	0.994	108.419	41.17%	98.08%
Ontario	42.308	17.40%	0.387	40.494	15.38%	34.37%
Manitoba	20.443	8.41%	0.991	21.893	8.31%	99.14%
Saskatchewan	2.415	0.99%	0.265	2.210	0.84%	21.35%
Alberta	1.415	0.58%	0.065	1.479	0.56%	5.10%
BC	40.958	16.84%	0.945	44.911	17.05%	95.12%
Yukon	(a)	(a)	(a)	0.221	0.08%	91.32%
NWT	0.600	0.25%	0.712	0.258	0.10%	59.72%
Total	243.193	100.00%	0.689	263.358	100.00%	66.60%
Atlantic	46.5	19.14%	78.6%	43.5	16.51%	75.3%
Quebec	88.5	36.40%	99.4%	108.4	41.17%	98.1%
Ontario	42.3	17.40%	38.7%	40.5	15.38%	34.4%
Prairies	24.3	9.98%	47.2%	25.6	9.71%	41.6%
B.C.	41.0	16.84%	94.5%	44.9	17.05%	95.1%
Canada	243.2	100.00%	68.9%	263.4	100.00%	66.6%

Note:
(a) included with North-West Territores

Table 4.14 reports the results of the two studies. The original results have been adjusted to 1984 price levels using the GNE deflator. This will be recognized as only a rough adjustment, since the price of electricity has not necessarily moved with the general price level over the past few years.

The Zuker and Jenkins estimate of C$6.6 billion is considerably above the Bernard, Bridges and Scott estimate of C$4.2 billion. Zuker and Jenkins are aware of the discrepancy but do not attempt to resolve it.

Both studies estimate very high rents for British Columbia. It is worth noting that these assume a moratorium on the construction of nuclear power plants in the province. If nuclear energy were admitted as an alternative, the estimated rent would fall by 50%. (Bernard, Bridges and Scott, p.38 and Table 6).

Although it is difficult to choose between the two estimates without a detailed investigation of both calculations, it would perhaps be best to prefer the Bernard, Bridges and Scott estimate both because it has allowed for the elasticity of power demand and because the exclusion of the nuclear alternative in BC has already biased the results upwards.

Table 4.14

Estimates of Rent From Hydroelectricity

	Bernard, Bridges and Scott		Zuker and Jenkins	
	per kWh	Total	per kWh	Total
A. 1979 C$	(mills)	(M$)	(mills)	(M$)
Churchill Falls	11.28	376.8		583.0
Quebec	9.94	785.8	18.64	1329.1
Ontario	5.09	214.9	7.17	763.2
Manitoba	5.30	100.4	29.82	521.8
B.C.	25.88	738.5	27.93	864.5
subtotal		2216.4		4061.6
other sources		615.6		329.9
Canada		2832.0		4391.5
B. 1984 C$	(mills)	(M$)	(mills)	(M$)
Churchill Falls	16.83	562.22		870.01
Quebec	14.83	1172.65	27.82	1983.42
Ontario	7.60	320.73	10.70	1138.92
Manitoba	7.91	149.83	44.50	778.68
B.C.	38.62	1102.06	41.68	1290.09
subtotal		3307.49		6061.13
other sources		918.70		492.31
Canada		4226.19		6553.44

Source:
Bernard, Bridges and Scott (1982) Table 6 and p.46.
British Columbia assume no nuclear alternative.
Rents are adjusted for elasticity of demand.
Zuker and Jenkins (1984) Tables 4-1 and 5-1.
Values in 1984 prices were calculated using the GNE deflator:
the adjustment factor is (300.4/201.3) = 1.492300

4.3.2 Waste Assimilation Services

Water provides a service to Canadians in transporting and assimilating wastes. Its capacity to do so is limited and varies from pollutant to pollutant. Organic pollutants, commonly measured by the Biological Oxygen Demand (BOD) of the discharged water, can often be completely assimilated given enough time. Others, such as toxic chemicals, are merely transported to other locations where they may pose hazards by accumulating in fish and other animals, including man.

The presence of large bodies of water, such as the St. Lawrence River, allows some Canadian communities to economize on sewage treatment by dumping untreated or lightly treated sewage into the river. Thus in the St. Lawrence River drainage basin only 7.7 percent of the municipal population is served by any form of wastewater treatment, in sharp contrast with the Lake Ontario shore drainage area in which 91.1% of the population is served.[13] The willingness to pay for this waste assimilation service is bcunded by the cost of treating the wastes before discgarge.

The average willingness to pay for waste assimilation clearly depends on what level of treatment would be required if the watercourse were not present. As shown in Table 4.3, Fraas and Munley (1984) report that the marginal cost of BOD removal varies from US$.25/lb at secondary treatment levels (70% of BOD removed, 1976 prices) and rises steeply to $.88/lb at advanced secondary treatment levels (90% removed). Table 4.15 applies the lower of these two estimates to the estimated total discharge of BOD by region in Canada.

The Fraas and Munley estimate is equivalent to C$1.02/kg of BOD removed. To remove 1.7 million kg per day at this rate would cost C$646 million per year. Over half of the implied savings accrue to Quebec.

This estimate, like all the others in this paper, must be treated with great caution. Use of the higher Fraas and Munley coefficient (for 90% BOD removal) would more than triple the estimated willingness to pay. Moreover, the use of water for waste assimilation imposes costs on downstream communities in the form of increase water supply costs, diminished recreational opportunities and increased health risks. In principle these costs should be deducted from the gross willingness to pay estimated above to obtain the net average WTP for water in this use.

Table 4.15

Value of Water for Waste Assimilation, by Region

	BOD5 (kg/day)	--Total Net WTP-- Low (M$/a)	High (M$/a)
Atlantic	158402	58.87	207.22
Quebec	870015	323.34	1138.16
Ontario	475868	176.86	622.54
Prairies	109758	40.79	143.59
B.C.	119752	44.51	156.66
North	2947	1.10	3.86
Canada	1736742	645.46	2272.03

Conversion Factors:			
Cost of BOD removal	0.25	0.88	1976 US$/lb
US Exchange Rate, 1976	0.9861	0.9861	C$/US$
Weight units	0.454	0.454	kg/lb
GNE deflator, 1976	160.2	160.2	
GNE deflator, 1984	300.4	300.4	
Cost of Bod removal	1.018222	3.584141	1984 C$/kg

Source: BOD discharge data from Statistics Canada, Environmental Statistics Program. Marginal cost of BOD removal from Fraas and Munley(1984)

4.3.3 Recreational and other Direct Uses

In addition to the uses of water considered so far, all of which have been indirect, Canadians derive utility directly from the existence of water. The most obvious direct use is for recreation. The recreational activities of millions of Canadians are centred around water. Water is essential to some of these activities, such as sports fishing, boating and swimming. For other activities, such as summer cottaging and camping, water greatly enhances the recreational experience.

Table 4.16 presents some selected statistics on the recreational use of water. In 1980 there were 3.9 million active anglers in Canada excluding Quebec.[13] Total fishing days (including an estimate for Quebec) numbered approximately 85 million and expenditures related to fishing exceeded 1.2 billion dollars (at 1980 prices). In addition, some 1.2 million households (15.5%) owned at least one type of recreational boat and 2.1 million households (27% of the total) owned some form of overnight camping gear. These data underline the prominent role which water-based recreation plays in Canadian society.

Unlike most of the uses considered above, recreational use of water typically leaves the water resource unaltered. Moreover, many people derive pleasure from the knowledge that high quality water-based recreational areas exist, even if they do not currently use them. They may place a value on the existence of water because they might use it in the future (option value), because they derive pleasure or consider it their ethical duty to preserve it (existence value) or because they wish it to be available for future generations (bequest value).

Because of the lack of markets for water in these uses, the measurement of these values of water has long been problematical. Over the past 15 years, however, there has been great progress made in developing techniques to address these issues. Much of the interest has been stimulated by the need to evaluate the costs and benefits of air and water pollution control in the United States. Freeman (1982) and Kneese (1984) both contain excellent discussions of these developments.

As suggested in section 3, the value of water in recreational and other direct uses is still to be measured by the minimum amount of compensation which would be accepted by the present users of the resource. There is considerable disagreement over whether it is reasonable to aproximate this amount by consumers' willingness to pay to retain environmental services which they presently enjoy. Some, for example Russell(1981) argue that the large discrepancies which are observed between estimates of

Table 4.16

Selected Data on Recreational Use of Water, Canada, 1980

	--Sports Fishing-- Days	Expen-ditures	Households Owning Boats	Camping Gear	Total House-holds
	(000)	(M$)	(000)	(000)	(000)
Province					
Newfoundland	1916	19.7	33	44	142
PEI	317	1.7	5	8	34
Nova Scotia	1503	12.2	43	69	253
New Brunswick	1637	21.0	25	47	196
Quebec	27111	370.6	228	449	2060
Ontario	37811	516.8	467	704	2873
Manitoba	2854	48.2	57	98	341
Saskatchewan	2088	42.9	55	101	306
Alberta	4511	62.6	102	285	675
British Columbia	5214	96.3	194	300	905
Yukon	154	4.2			
NWT	183	9.8			
Canada	85299	1206.0	1209	2105	7785
Region					
Atlantic	5373	54.6	106	168	625
Quebec	27111	370.6	228	449	2060
Ontario	37811	516.8	467	704	2873
Prairies	9453	153.7	214	484	1322
BC	5214	96.3	194	300	905
Canada	85299	1206.0	1209	2105	7785

Source:
Statistics Canada, 87-401 (1980-81)
Fishing data in Quebec were not reported and are estimated from Ontario data using household shares.

the willingness to accept compensation (WTA) and willingness to pay are the result of strategic behaviour on the part of survey respondents, while others, for example Meyer (1979 and 1981) argue that market based willingness to pay measures do systematically undervalue true WTA and that the continued use of these low estimates has led to their rejection by many fish and wildlife agencies.

Regardless of the outcome of this debate, most reported estimates of recreational values have been based on the willingness to pay concept. A number of methods have evolved to measure WTP. They are discussed in Freeman (1982), Knesse (1984) and also reviewed in the Canadian context by Adamowicz and Phillips (1983). Among these are the contingent valuation method, the travel cost method and the hedonic price index method.

Contingent valuation studies attempt to derive WTP estimates by directly asking survey respondents what payment they would be willing to make to preserve or improve environmental quality. Considerable care must be taken to fully inform the respondents of the nature of the environmental change being considered and of the vehicle for payment. Schulze, d'Arge and Brookshire (1981) argue that contingent valuation studies conform reasonably well to estimates obtained by alternative techniques and that strategic bias is unimportant. See, however, Rowe and Chestnut (1983) for a vigorous rebuttal.

Hedonic price studies derive a willingness to pay estimate from data relating expenditures on water related activities to days spent, income, and other variables measuring the quality of the experience. Finally, the travel cost method exploits the fact that people travelling different distances to recreational areas face different implict costs to derive a demand curve for the recreational experience. Willingness to pay estimates can then be derived from the demand function.

Table 4.17 summarizes some of the recent studies which have reported average willingess to pay for water based recreation. The Canadian study, by Adamowicz and Phillips, reports substantially higher average willingness to pay for fishing than do the American studies. This may reflect special characteristics of fishing in Alberta or of their sample.

A number of studies have attempted to measure the benefits caused by improved water quality. These would represent the value of high quality water to those currently enjoying it. The Smith, Desvousges and McGivney study reports average gross WTP for a change from boatable to swimmable water equivalent to $28.25 per household. A great deal of this willingness to pay is in fact paid in the form of costs incurred in travelling to the recreational site. The net willingness to pay, and hence the value of the raw water, is closer to $4.00 per household per year.

Table 4.17

Estimated Value of Water-Related Recreational Benefits

Study	Description	Units	Original Estimate	1984 Equi-valent
Adamowicz and Phillips (1983)	Survey of Alberta Resident Fishermen			
	Average net WTP/day, Contingent Valuation	1976 C$	39.44	73.96
	Average gross WTP/day, hedonic price function	1976 C$	35.43 37.81	66.44 70.90
	Marginal WTP/day Travel Cost	1976 C$	2.09 4.18	3.92 7.84
Vaughan and Russell (1982)	Survey of US fee-fishing sites, 1979			
	Average net WTP/day, trout, travel cost	1979 US$	10.96 19.49	19.66 34.96
	Average gross WTP/day trout, travel cost	1979 US$	15.6 24.09	27.98 43.21
Smith,Desvousges, McGivney (1983)	Survey of WTP for improvement from boatable to swimmable water, Pennsylvania, travel cost			
	average gross WTP per household-season	1977 US$	14.71	28.75
	average net WTP per household-season	1977 US$	2.03	3.97

Table 4.17
(continued)

Estimated Value of Water-Related Recreational Benefits

Study	Description	Units	Original Estimate	1984 Equi- valent
Greenly, Walsh, Young (1981)	WTP for high quality water, Colorado, contingent valu- ation, using sales tax.			
	Option Value	1976 US$	34.05	66.59
	Bequest Value		16.97	33.19
	Existence Value		24.98	48.86
	Recreation Value		56.68	110.85
	Total		121.23	237.10

Note:
Where appropriate the low and high estimates are reported.

Exchange Rates	
1976 US$/C$	1.0430
1977 US$/C$	1.1157
1979 US$/C$	1.2019
GNE deflators	
1976	160.2
1977	171.5
1979	201.3
1984	300.4

Finally, some progress has been made on estimating the non-participatory values of water. The Greenly, Walsh and Young study indicates that residents of Colorado place very high values (of the order of C$237 per household per season) on the preservation of high quality recreational water. The non-participatory values -- existence, bequest and option -- accounted for more than half the estimated willingness to pay.

The current literature clearly indicates the importance of site specific characteristics in determining the willingness to pay for water-based recreation. This fact, together with the wide range in values obtained by different methods, should make us cautious in estimating any sort of national total value of water in recreational uses. To indicate the order of magnitude, however, Table 4.18 reports a calculation of the total willingess to pay for sports fishing in Canada. Rather than relying exclusively on the Adamowicz and Phillips values, which seem particularily high, the table has been calculated with the WTP estimates for trout fishing from Vaughan and Russell (C$19.96 and 34.96 per day).

The results are striking. The total willingness to pay for sports fishing uses of water ranges from $1.7 billion to $6.3 billion. This is the same order of magnitude as the value of water in hydroelectricity generation and far greater than any other use we have identified, with the exception of municipal water.

To this figure must be added recreational benefits from boating, swimming and cottaging and the non-participatory benefits of existence, option and bequest values. Since the fishing benefits alone are of the same order of magnitude as the hydroelectric benefits, we must conclude that recreational and related values of water are likely to be substantially greater than the sum of the production values we have examined until now.

Table 4.18

Estimated Value of Recreational Fishing, by Region

	Days (000)	Total Net WTP Low (M$)	Total Net WTP Medium (M$)	Total Net WTP High (M$)
Province				
Newfoundland	1916	37.7	67.0	141.7
PEI	317	6.2	11.1	23.4
Nova Scotia	1503	29.5	52.5	111.2
New Brunswick	1637	32.2	57.2	121.1
Quebec	27111	533.0	947.8	2005.1
Ontario	37811	743.4	1321.9	2796.5
Manitoba	2854	56.1	99.8	211.1
Saskatchewan	2088	41.1	73.0	154.4
Alberta	4511	88.7	157.7	333.6
British Columbia	5214	102.5	182.3	385.6
Yukon	154	3.0	5.4	11.4
NWT	183	3.6	6.4	13.5
Canada	85299	1677.0	2982.1	6308.7
Region				
Atlantic	5373	105.6	187.8	397.4
Quebec	27111	533.0	947.8	2005.1
Ontario	37811	743.4	1321.9	2796.5
Prairies	9453	185.8	330.5	699.1
BC	5214	102.5	182.3	385.6
Canada	85299	1677.0	2982.1	6308.7
Average Net WTP ($/fishing-day)		19.66	34.96	73.96

Source:
Statistics Canada, 87-401 (1980-81) and Table 4.17.
Fishing data in Quebec were not reported and are estimated from Ontario data using household shares.

4.3.4 Commercial Navigation and Fishing

The final indirect uses of water to be considered are commercial navigation and fishing. While important in specific localities and for individual participants, these activities are much less significant in terms of total value. Unfortunately, no published studies of average willingess to pay for these activities were found.

For all practical purposes, freshwater commercial navigation in Canada is confined to Great Lakes-St. Lawrence Seaway and the MacKenzie River. Table 4.19 presents some selected data on the operations of the St. Lawrence Seaway. Total revenues for that year were $57.9 million dollars. Grains, iron ore, coal and coke, and iron and steel products accounted for almost 85% of tonnage.

The net willingness to pay for water transportation is limited by the cost of available subsititutes, in particular rail transportation. Time did not permit an investigation into the freight differential for the cargoes carried in commercial freshwater navigation. However, it does appear that the true net WTP is very low, if not negative , since the Seaway habitually operates at a loss. Operating losses on total operations, including the profitable Thousand Islands Bridge, were $9.7 million in fiscal 1982-83 and $3.5 million in 1983-84.[14], 1983. These losses include depreciation but not the opportunity cost of the invested capital. The accumulated deficit was $190 million in March, 1984.

Consistent losses indicate that the Authority was unable or unwilling to charge prices which reflect the average cost of operating the Seaway. This probably indicates that shippers are unwilling to pay tolls sufficiently high to cover the real rsource costs of water navigation and hence that their net willingess to pay for water in this use is zero or negative.

Table 4.20 reports data on some aspects of freshwater commercial fishing in Canada. The freshwater fishery is much smaller than the salt-water one. Only about 8000 fishermen are involved, and the value of commercial landings was only $58.8 million in 1982. This amounted to an average of $7,176 per fisherman, with a high value of $17,467 in Ontario outweighing very low returns in the other provinces and territories. This is probably due to the fact that commercial fishing outside of Ontario is generally a part time activity often employing native workers in remote communities.

Table 4.19

Selected Operating Statistics, St. Lawrence Seaway, 1982

	Montreal-L.Ontario	Welland Canal	Total
Cargo by Toll Classification (million tonnes)			
Bulk n.e.s.	15.01	21.49	36.50
Grain	24.25	25.18	49.43
General Cargo	3.18	2.01	5.19
Other	0.37	0.35	0.72
Total	42.82	49.02	91.84
Traffic Revenue by Toll Classification, (M$)			
Bulk n.e.s.	11.60	6.60	18.20
Grains	11.64	7.76	19.40
General Cargo	6.05	1.00	7.06
Gross Registered Tonnage	3.83	4.40	8.22
Others	0.22	4.77	4.98
Total	33.33	24.53	57.86
Vessel Transits (Number)			
Loaded Cargo	2693	2961	
Ballast Cargo	1434	1990	
Other	249	233	
Total	4376	5184	

Source:
St. Lawrence Seaway Authority, The Seaway, 1982

Table 4.20

Selected Statistics, Freshwater Fisheries, 1982

	N.B.	Que.	Ont.	West	Total
Registered Fishing Vessels					
Number	41	412	1122	1976	3551
Value (thousand $)	108	433	27215	NA	NA
Registered Fishermen					
Number	108	437	2106	5550	8201
Catches					
nominal catch (t)	NA	NA	34110	21974	57743
landed value ('000 $)	NA	NA	36788	20089	58847
Average Value of Catch per registered Fisherman			17468	3620	7176

Source:
Department of Fisheries and Oceans, Canadian Fisheries: Annual Statistical Review, 1982

Once again it would appear that the net WTP for water for commercial fishing is very low. Salt water fish provide a convenient, low cost substitute, and hence the elasticity of demand is likely to be high and the consumers' surplus low. It is difficult to believe that gross revenues even as high as 17 or 18 thousand dollars per fisherman are sufficient to cover the true opportunity cost of labour in the fishery, much less the opportunity cost of the invested capital. By the same argument as advanced above, the social net WTP for commercial freshwater fishing must be negative.

Part of the blame for this situation may be inappropriate licencing policies. It is well known[15] that unless careful attention is given to controlling access to fisheries they will become overcrowded and the potential rents will be driven to zero. However it is likely that competition from salt-water fish is sufficiently strong to reduce freshwater rents to close to zero anyway. The only exception would occur in remote settlements where the opportunity cost of labour is very low and the fishery is one of the few sources of earned income.

4.4 Conclusion

In this section we have attempted to provide some indication of the economic value of water in various uses. Our measure of economic value is users' net willingness to pay to maintain water in its current use.

For each use, our approach has been to report selected statistics on the price, cost and quantity of water currently devoted to that use. Where possibile, estimates of demand elasticities were also reported. Then we surveyed the published literature to obtain estimates of average net willingness to pay. The values were converted to 1984 Canadian dollars and price levels and then applied to the current quantity estimates to obtain total net willingness to pay for raw water.

Throughout the section we emphasized the tentative nature of these estimates and noted in particular that truly meaningful estimates of the economic value of water in any use require much more specific information on the nature of the change in water supply being contemplated and the alternatives available. Nevertheless, the order of magnitude of the various estimates provides considerable insight into the value of water in the Canadian economy.

Table 4.21 summarizes our results. Where possible, a range of values has been indicated. The total willingness to pay for the identified uses ranges from $7.5 billion dollars to $23.0 billion dollars annually (at 1984 prices).

The greatest uncertainty lies in the estimates of the value of water for municipal use, which run from $288 million to $7 billion. This is because some minimum supply of residential water is as close to an necessity as any economic good can be. Consequently estimates of the total consumers' surplus derived from access to residential water are extremely high. However, the total consumers' surplus from residential water greatly overstates the willingness to pay for raw water from current sources if any reasonable substitutes are available. The low value in Table 4.21 assumes that alternative water supplies can be obtained for an increase of 20% in the average cost of municipal water supply.

The second greatest uncertaintly lies with the recreational value of water, as indicated by the estimated willingness to pay for fishing. Based on published estimates of the value of a fishing day, the total willingness to pay for sports fishing could range from $1.7 to $6.3 billion. It is important to notice that the willingness to pay for sports fishing is quite comparable to the willingness to pay for hydroelectricity, which ranges from $4.2 billion to $6.6 billion. Benefits from other recreational uses of water and from non-participatory values of water (such as option, existence and bequest value) were shown to be very substantial but it was not possible to derive a national total.

It seems clear that recreational, municipal and hydroelectric uses of water dominate the total willingness to pay estimates. The total value of water in industrial use is estimated at less than $1 billion and the estimated value of water for commercial navigation and fishing appears close to zero.

Table 4.21

Selected Estimates of the Economic Value of Water, Canada

Use	---Average Net WTP-- Low ($/Ml)	High ($/Ml)	----Total Net WTP--- Low (M$)	High (M$)
Municipal	100	2430	288	6968
Irrigation	0	36	0	109
Thermal Power	9	9	169	169
Industrial Uses				
Paper	87	87	251	251
Chemical	76	76	217	217
Primary	16	43	44	118
Petroleum	19	19	10	10
Food & Beverages	124	124	53	53
Subtotal			613	1343
Total Withdrawal Uses			1070	8590
Hydroelectricity			4226	6553
Waste Assimilation(a)	1	4	645	2272
Sports Fishing (b)	20	74	1677	6309
Seaway Navigation			0	0
Freshwater Fishery			0	0
Total Instream			6549	15134
Grand Total			7619	23724

Notes:
(a) Average WTP in C$/kg of BOD removed.
(b) Average WTP in C$/fishing day.

5 LIMITATIONS AND FURTHER CONSIDERATIONS

In addition to the estimates of the economic value of water presented in section 4, the terms of reference for this study require us to consider other indicators of the value of water to Canadians for which economic data are unavailable or inadequate. To a large extent, this requirement has been met by the supplementary data presented in sections 2 and 4. In this section we review some of these indicators and comment further on the limitations of the economic data discussed above. These limitations may be conveniently discussed under the two headings of coverage and concept.

5.1 Coverage

The average willingness to pay estimates presented in section 4 cover all the important withdrawal uses of water, as indicated by the discussion in section 2. Instream uses of water, however, were not covered as thoroughly. In particular, although we provided an estimate of the value of sports fishing in Canadian fresh waters we did not provide any indication of the the value of other recreational uses of the water. Some of these uses are swimming, boating, and cottaging. Table 4.16 indicated that approximately 1.2 million Canadian households, 15.5% of the total for 1980, owned at least one boat, and 2.1 million owned overnight camping gear. These data indicate that outdoor recreation, much of it water-based, is central to the activities of a large fraction of the Canadian public. The study by Greenly, Walsh and Young (1981), indicates that willingness to pay to preserve high quality recreational uses of water range may be as high as $110 per household in the Denver, Colorado, area and it is reasonable to expect that Canadians would be willing to pay equivalent amounts. Other uses of water which were not considered include the use of water to support wildlife and as a vehicle for hunting and fishing by Canada's native peoples. The submissions of the Canadian Nature Federation (exhibit #134) and the Athabasca Chipewyan Indian Band (exhibit #36) to the Inquiry on Federal Water Policy provide good discussions of these aspects of water use. The former cites a Canadian Wildlife Survey indicating that 85 percent of Canadians participated in some activity related to wildlife and that $4.2 billion were spent annually on such activities. The latter shows how fluctuations in water levels caused by hydroelectric development far upstream can dramatically affect the fish and wildlife harvesting activities of native peoples.

The total willingness to pay for water to maintain wetlands is undoubtedly very high, since waterfowl hunting is a popular sport both in Canada and the United States. On the other hand, the native population of Canada constitutes such a small fraction of the total population that any attempt to place a total WTP estimate on their use of fishing and hunting resources is bound to be insignificant in comparison with the very large values estimated for hydroelectricity and sports fishing. However this fact should not blind us to the moral obligations that many Canadians feel towards native peoples. In all probability Canadians generally would be willing to pay significant sums to preserve or extend opportunities for native people to earn a dignified livlihood.

Willingness to pay for preservation of native peoples' rights to use water is an example of a wider class of benefits which Canadians receive from water without directly participating in its use. Authors such as Bocking (1972, ch. 10) have argued forcefully that water and water-based activities are central to Canada's national identity. Canadian history was built on the navigation of the great East West canoe routes by the early fur traders. The beaver is a national symbol recognized world wide. Salt water fishing has always been a central activity on both the Atlantic and Pacific coasts, and boatbuilding provided an early foundation for the maritime economies. Lumber, another great Canadian staple product, was rafted down countless rivers to the sawmills before the advent of forestry roads and trucks.

Appeals to the importance of water in the national tradition are implicit arguments that Canadians are (or should be) willing to pay substantial amounts to preserve these waters in something approaching their natural state. Formally speaking, this is an existence value. Existence value may also arise from ethical or religious convictions that place importance on maintaining the integrity of the natural environment.

Additional non-participatory values of water include option value[16] and bequest value. Option value is the amount people are willing to pay to maintain the option of leaving an environmental asset in its natural state rather than committing it to irreversible development. This value may arise either from risk aversion or from the probability of aquiring additional information in the future which will indicate whether development is desirable. Bequest value arises from the fact that many people derive pleasure from the knowledge that natural environments will be available for the enjoyment of future generations. Greenly, Walsh and Young (1981) and Walsh, Loomis and Gillman (1984) report that these non-participatory values may be comparable in magnitude to the willingness to pay for recreational activities. For example, in the study of Colorado residents reported in section 4, non-participatory values accounted for more than half of an estimated willingness to pay of $237 per household per year.

5.2 Conceptual Limitations

In addition to the limitations in coverage noted above, it is important to understand a number of conceptual limitations of the average willingness to pay estimates which have been presented. These include the limited usefulness of average values, the need for precisely specified alternatives, the use of willingness to pay rather than required compensation and neglect of future prices and the irreversibility of investment in water projects.

The first three of these need be mentioned only briefly since they have been discussed at length elsewhere in this study. As explained in section 3, average net willingness to pay for water is a good guide to resource allocation when the decision is to allocate large blocks of water amongst mutually exclusive uses such as waste assimilation and recreation. In many cases, however, water can be reallocated among uses in fairly small increments, as is would be the case when irrigation water is reduced to provide additional industrial process water. Under these circumstances it is the marginal value of water, not the average, which should be considered. As noted above, unless there is quantity rationing, the marginal value of water will generally equal its price.

As stressed throughout the study, average and total values cannot be assigned to water without comparing current uses with a particular, well specified alternative. These alternatives will vary from locality to locality and can rarely be described in advance of a specific project proposal.

As noted in section 3, the use of WTP estimates to approximate willingness to accept compensation for the loss of water poses difficulties. Although analysts are not fully agreed, there is a substantial body of opinion holding that WTP estimates seriously underestimate the loss experienced by people deprived of access to water-based resources. Probably the same holds for non-participatory uses of water. This is important because individual users rarely have the chance to decide individually whether or not to accept compensation for a water development project. <u>Thus we have very little market based information on which to calculate the value of water to non-participants and recreational users and we run the risk of depriving these groups of their access to water without appropriate compensation</u>.

A limitation not yet considered is imposed by the long life and fundamental irreversibility of water resource projects. Not only does the construction of a hydroelectric dam irrevocably alter the physical environment above the reservoir but also commitments to export water or water-based power are likely to be difficult to terminate.

Porter (1982) and Fisher (1983) provide useful expositions of the consequences of irreversibility. The most important consequences are that present decisions about the allocation of water resources must take into account the probable trends in prices in the future as well as the probability that over time more information about the benefits or damages from an environmental project is likely to become available.

The logic behind this position is simple. Because of the dwindling supply of natural environments and the increasing demand for recreational activities associated with them, the willingness to pay for the preservation of the environment is likely to grow over time. At the same time, increasing technological developments are likely to render the gains from developing water resources progressively smaller. Consequently today's value for water in non-consumptive uses is probably an underestimate of its future value and irreversibly reallocating water to development uses may impose costs greater than the benefits obtained. Fisher (1983) argues that this, together with possibility that improved information about the consquences of development will emerge in the future, constitutes a strong argument in favour of a conservative approach to the development of natural resources.

5.3 Summary

The estimates of the economic value of water presented in section 4 are subject to important limitations, both in coverage and in concept. Recreational uses of water have been underestimated by focussing solely on sports fishing, non-participatory uses of water have not been quantified and the role of water in supporting wildlife and providing a vehicle for native subsistence activities has been ignored. This probably results in a serious underestimation of the value of water in non-consumptive uses.

Conceptually, the estimates of average net WTP are not always the most appropriate guide to resource allocation. They also require better specification of the alternatives to current water. Willingness to pay underestimates the true value of water to those who currently have the right of access, and finally the long life or irreversibility of water development projects requires us to consider future price trends before undertaking development.

6 Summary and Conclusions

This study was undertaken for the Inquiry on Federal Water Policy. The main objective was to estimate the value of water both to major economic sectors and to Canadian society in general. A subsidiary objective was to clarify the conceptual problems mentioned in the Specifications for Research.

Section 2 of the study reviewed a number of statistical accounts of value of production, employment, and public and private expenditure on water related activities in Canada. The main finding was that water use is highly concentrated in three non-manufacturing industries (agriculture, electric power and municipal waterworks) and in four manufacturing industries (chemical products, petroleum products, paper and allied products, and primary metal products). These seven industries accounted for 13.1% of total Canadian Gross Domestic Product, 8.9% of employment, 91.7% of estimated water intake and 89.8% of estimated water consumption. Total public and private expenditures on water related activities were about 2% of GDP ($6.5 billion in 1981). One half of this was spent on the construction of electric power generation and a further third on municipal water supply and wastewater treatment.

Section 3 attempted to clarify the conceptual issues involved in estimating the value of water. In section 3.1, the value of water was defined as the payment which would fully compensate Canadians for loss of access to water. It was stressed that an adequate measure of value requires a detailed specification of the conditions before and after the loss of access.

Section 3.2 established that the concept of value of water is equivalent to the concept of benefit in cost benefit analysis. This allowed us to apply the theory of cost-benefit analysis to the question of measuring values. It was shown that the total value of raw water (water in the watercourse) equals the consumers' and producers' surplus arising from the production and delivery of water-based products and recreation. For withdrawal uses of water, this value can be expressed as average net willingness to pay for the raw water withdrawn or consumed. Average net willingness to pay for water is the difference between the average gross willingness to pay for a water-based product and the average cost of producing and delivering it.

Section 3.2 also established that the average net willingness to pay for water is an appropriate concept for allocating water in large blocks among mutually exclusive uses. However, if small adjustments can be made to the amount of water allocated to each user, the relevant concept is marginal value. In the absence of water rationning, the marginal value of water will equal its price.

Section 3.3 considered three specific approaches to measuring value: value added, the cost of the next best alternative, and willingness to pay. Value added was shown to be an unsuitable measure of value except under extreme conditions. All suitable measures of value must ultimately be based on a notion of willingness to pay. Under some circumstances the cost of the next-best alternative source of water is a good estimate of willingness to pay. However, it will seriously overstate the value of water if the demand for the water-based product is highly elastic.

Section 4 attempted to estimate average and total net willingness to pay for water in a number of uses. In general, basic price and quantity data for the use in question were reported, together with estimates of demand elasticity when available. The available literature was surveyed, and estimates of willingness to pay were adjusted to 1984 Canadian price levels. The adjusted average willingness to pay was applied to estimates of Canadian water intake to obtain estimates of the total value of water in these uses.

The results indicated that the total net willingness to pay for raw water in Canada may range from $7.5 to $23.0 billion dollars annually. The range of uncertainty is particularly large in the case of municipal water supplies, since the total value of the minimum amount of water required for personal survival is extremely high. There is also a great deal of uncertainty in the range of values for sports fishing.

The estimates clearly indicate that besides municipal use, hydroelectric power generation and sports fishing are by far the most important of the identified uses. Total willingness to pay for water in each of these uses could be over $6 billion per year.

Section 5 discusses limitations of the estimated values. A number of important uses of water were not discussed. Prominent among these were the non-fishing recreational use of water and the non-participatory benefits arising from the existence of water and the possibility of conserving it and bequeathing it to future generations. Indications are that the net willingness to pay for water in these uses may be very substantial and of the same order of magnitude on sports fishing benefits.

The estimates must be interpreted with a great many cautions. First, to be useful in allocation decisions, estimates of willingness to pay must be based on a much more specific description of the alternatives under consideration than was possible in this study. A truly satisfactory estimate of the value of water can only be obtained through the careful examination of each individual case in which an estimate is required. Secondly, measured willingness to pay to prevent the loss of an environmental commodity will normally understate the true value of the commodity, as measured by the payment required to fully compensate for its loss. Finally, the fact that water development projects are long-lived and largely irreversible means that future trends in prices must be taken into account in allocation decisions. This frequently suggests a conservative stance in assessing water development projects.

1. _Canada Water Year Book_ 1981-1982. Environment Canada, 1983, pp.

2. Gardner Pinfold Consulting Economists, Ltd. _A Study of Water in the Economy of Atlantic Canada_. Prepared for Environment Canada, Inland Waters Directorate, March 31, 1983

3. _Public Expenditure in the Water Industry, 1979-1981_, Economic Analysis Section, Inland Waters Directorate, Environment Canada, June, 1984.

4. _A Study of Water in the Economy of Atlantic Canada_, op.cit.

5. _A Study of Public Expenditure in the Water Industry_, op.cit.

6. These were provided through the generous cooperation of Don Tate of the Inland Waters Directorate.

7. Concise Oxford Dictionary

8. See, for example, Freeman (1978 and 1982), Feenberg and Mills (1980) and Kneese (1984).

9. See Adamowicz and Phillips (1983) and references therein, also Russell (1982) and Meyer(1982).

10. See Tversky and Kanneman (1982).

11. Based on estimates from Environment Canada, Water Planning and Management Branch.

12. Fraas and Mundley (1984) report a cost elasticity of .79 with respect to flow changes.

13. Data from Statistics Canada, Environmental Statistics Program, based on the MUNDAT data base.

14. Statistics Canada, _Travel, Tourism and Outdoor Recreation_, 1980-81. Quebec data were unavailable at the time of publication.

15. St. Lawrence Seaway Authority, _Annual Report_

16. See Munro (1982).

17. see V.K. Smith (1983)

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